

Sonographic Measurement of Spleen in Relation to Age: A Prospective Study among Adult Nepalese People in Western Nepal

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ABSTRACT

Introduction: Splenomegaly is an enlargement of the spleen which is a quite common problem in any part of the world. Spleen is enlarged in various clinical disorders e.g. infections, metabolism or storage disorders and hematological abnormalities. Splenomegaly is an indicator of pathologic process that may be of primary splenic origin but also may be a reflection of disease in virtually any other organ system. Thus, it is important to estimate the splenic size *in vivo* in the diagnosis, treatment and prognosis of a variety of disorders.

Objective: The objective of this study was to determine the normal dimension of the spleen in the adult Nepalese people.

Methods: This is a prospective study in which 320 adults subjects were scanned by using 3.5 MHz curvilinear probe. We used ultrasonography to examine 160 males and 160 females, not to have any condition likely to be associated with splenic enlargement. The measurement for the length and thickness of spleen were obtained in right lateral position.

Results: This study revealed the splenic dimensions for males were greater than in females. The men spleen length were (10.07 ±0.7 cm, 10.1 ±0.54 cm, 9.5 ±0.7 cm and 9.0 ±0.43 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively). The females spleen length were (9.83 ±0.53 cm, 9.58 ±0.58cm, 9.2 ±0.64 cm and 8.8 ±0.36 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively). The men spleen thickness were more (4.1 ±0.5 cm, 4.05 ±0.58 cm, 3.43 ±0.38 cm and 3.0 ±0.36 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively). The females splenic thickness were 4.06 ±0.47 cm, 3.78 ±0.48 cm, 3.38 ±0.35 cm and 2.29 ±0.23 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively. Thus significant differences between male and female splenic dimensions were found for each age group chosen (P <0.05).

Conclusions: The results show that the splenic length and thickness decreased with increase in age in both males and females and all the dimensions were greater in males than in females. This study established normogram that can be more reliably used as both a complementary modality to clinical evaluation and as a more sensitive means of evaluating and screening patients for splenic disorders for any pathological enlargement or reduction of size in clinical practice in a Nepalese populations.

Keywords

Spleen, Ultrasonography, Western Nepal.

Abbreviations

CT (Computed Tomography)

MRI (Magnetic Resonance Image)

USG (Ultrasonography)

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INTRODUCTION

Splenomegaly is an enlargement of the spleen which is a quite common problem in any part of the world. It may occur in the setting of acute or chronic disease though it is not a diagnosis in itself. Spleen is enlarged in various clinical disorders e.g. infections, metabolism or storage disorders and hematological abnormalities¹. Splenomegaly is an indicator of pathologic process that may be of primary splenic origin but also may be a reflection of disease in virtually any other organ system. Thus, it is important to estimate the splenic size *in vivo* in the diagnosis, treatment and prognosis of a variety of disorders. Prior to the advent of ultrasonography and other tomographically based imaging modalities, it was difficult to image the spleen. Clinical evaluation of the splenic size is difficult and unreliable due to the spleen being concealed in its anatomic location under the ribs and considerable enlargement needing to occur before the spleen is clinically palpable².

There are many modes of investigation to identify the enlarged spleen e.g. plane radiograph, sonography, computed tomography (CT), magnetic resonance image (MRI) and radionuclide scan. Out of these modalities sonography and computed tomography are most reliable for intra-abdominal organs³. Modern sophisticated CT scan and MRI can also be used for measuring splenic size accurately but they are very costly. Ultrasound has been found to be both accurate and reliable⁴. Indeed, it has made possible, direct visualization and assessment of abdominal organs and a cheap imaging modality that is realistic for developing nations like Nepal.

Due to lack of studies in normal range of spleen size in Nepalese adults by age, splenic measurements are based on referring to the data given by European or American studies. But we can't deny the established facts of variations in the anthropometric features of various populations, races and regions. The diverse climate of the zones and the socio-economic status of Nepalese people make the study population special. To the best of our knowledge, there is no prior comprehensive anthropometric study has conducted on the normal measurements of spleen by ultrasonography in Nepalese adults. Thus a normogram of splenic sizes based on a normal Nepalese population would provide more reliable values that would confidently detect minimal changes in splenic size and thus predicate early splenic pathology.

METHODS

Clearance from the institutional ethical committee was obtained prior to study. This is a prospective study in

which 320 adults subjects were scanned by using 3.5 MHz curvilinear probe with a model LOGIQ5 premium ultrasound machine. We used ultrasonography to examine random sample of 320 patients, including 160 males and 160 females from 16 to 75 years of age living in the Western region of Nepal who had visited Radiology Department of Gandaki Medical College Teaching Hospital, Pokhara, Nepal. Only the patients who did not have any condition likely to be associated with splenic enlargement were included in the study. All measured spleens had a normal position, shape and normal textures.

Ultrasound examination of spleen were performed according to Arora *et al* (2010)⁵. The length and thickness of spleen were obtained in right lateral position. Splenic measurement was taken during deep inspiration, to minimize masking by the lung. Splenic length was measured on longitudinal coronal image from dome to tip through the hilum (Fig 1) followed by thickness measurement taken in the longitudinal coronal plane at a point bisecting the line indicating length (Fig 2). To determine reproducibility, each measurement was repeated at least three times and most repeated value was recorded.

Fig 1: Showing measurement of length of spleen

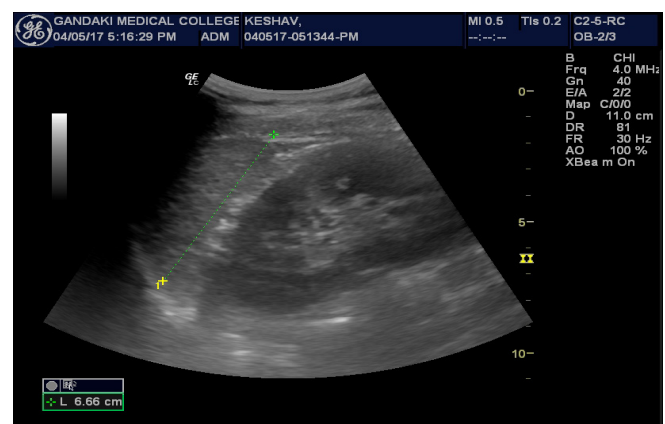
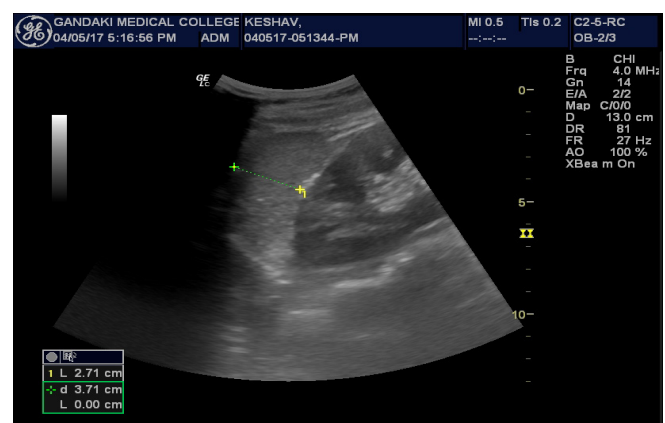


Fig 2: Showing measurement of thickness of spleen



STATISTICAL ANALYSIS

All samples data were tabulated in a master chart and entered in data sheet Graph pad prism version 6. Statistical analysis was carried out with Graph pad prism; a computer software program. The difference among the gender was analyzed by unpaired t-test. The difference among age groups was analyzed by one way ANOVA test and comparing each age group by Dunnett's multiple comparison test.

RESULTS

The splenic length and thickness were measured with respect to the age and sex with the help of ultrasound. There were 320 people subjected to this study who were from different parts of the Western region of Nepal. Among them 160 were males and 160 were females. It was observed that mean splenic length of age group 16 - 30 years was 10.07 ± 0.7 cm for males. The splenic length of age 31 - 45 years male group was 10.1 ± 0.54 cm. The splenic length for age 46 - 60 years male group was 9.5 ± 0.7 cm and splenic length for 61 - 75 years male age group was 9.0 ± 0.43 cm (Table 1). It was observed that mean splenic length for age 16 - 30 years female group was 9.83 ± 0.53 cm. The splenic length of age 31 - 45 female group was 9.58 ± 0.58 cm. The splenic length for age 46 - 60 years female group was 9.2 ± 0.64 cm and splenic length for age 61 - 75 years female age group was 8.8 ± 0.36 cm (Table 2).

Table 1: Length of spleen among male subjects

Age (Years)	Number	Mean (cm) \pm SD	Range (cm)
16 - 30	40	10.07 ± 0.7	8.9 - 11.9
31 - 45	40	10.1 ± 0.54	9.3 - 11
46 - 60	40	9.5 ± 0.7	8.3 - 10.5
61 - 75	40	9.0 ± 0.43	7.9 - 9.6

Table 2: Length of spleen among female subjects

Age (Years)	Number	Mean (cm) \pm SD	Range (cm)
16 - 30	40	9.83 ± 0.53	8.9 - 10.9
31 - 45	40	9.58 ± 0.58	9.0 - 10.6
46 - 60	40	9.2 ± 0.64	8 - 10.4
61 - 75	40	8.8 ± 0.36	7.9 - 9.5

It was observed that mean splenic thickness for age 16 - 30 years male group was 4.1 ± 0.5 cm. The splenic thickness

for age 31 - 45 years male group was 4.05 ± 0.58 cm. The splenic thickness for age 46 - 60 years male group was 3.43 ± 0.38 cm and splenic thickness for 61 - 75 years age group was 3.0 ± 0.36 cm (Table 3). It was observed that mean splenic thickness for age 16 - 30 years female group was 4.06 ± 0.47 cm. The splenic thickness for 31 - 45 years female group was 3.78 ± 0.48 cm. The splenic thickness of age 46 - 60 years female group was 3.38 ± 0.35 cm and splenic thickness for age 61 - 75 years female group was 2.29 ± 0.23 cm (Table 4).

Table 3: Thickness of spleen among male subjects

Age (Years)	Number	Mean (cm) \pm SD	Range (cm)
16 - 30	40	4.06 ± 0.47	3.3 - 4.8
31 - 45	40	3.78 ± 0.48	3 - 4.5
46 - 60	40	3.38 ± 0.35	3 - 4.1
61 - 75	40	2.29 ± 0.23	2.5 - 3.3

Table 4: Thickness of spleen among female subjects

Age	Number	Mean (cm) \pm SD	Range (cm)
16 - 30	40	4.1 ± 0.5	3.3 - 4.9
31 - 45	40	4.05 ± 0.58	3 - 5.2
46 - 60	40	3.43 ± 0.38	2.7 - 4.1
61 - 75	40	3.0 ± 0.36	2.6 - 4.0

Table 5: Showing ANOVA test for splenic length for males of different age groups

ANOVA table	SS	DF	MS	F (DFn Dfd)	P value
Between column	49.01	3	16.34	$F(3,156) = 51.85$	$P < 0.001$
Within column	49.16	156	0.315		
Total	98.17	159			

Table 6: Showing Dunnett's multiple comparison test for splenic length of males for different age groups

Dunnett's multiple comparisons test	Mean Diff.	95.00% CI of diff	Significant	Summary	Adjusted P value
Age 16 - 30 vs age 31 - 45 years	0.24	-0.05 to 0.54	No	ns	0.1370
Age 16 - 30 vs age 46 - 60 years	0.84	0.54 to 1.14	Yes	***	0.0001
Age 16 - 30 vs age 61 - 75 years	1.42	1.12 to 1.72	Yes	****	0.0001

Table 7: Showing ANOVA test for splenic length for females of different age groups

ANOVA table	SS	DF	MS	F (DFn Dfd)	P value
Between column	20.44	3	6.813	F(3,156) = 23.47	P <0.001
Within column	45.28	156	0.2902		
Total	65.72	159			

Table 8: Showing Dunnett’s multiple comparison tests for splenic length of males for different age group

Dunnett’s multiple comparisons test	Mean Diff	95.00% Cl of diff	Significant	Summary	Adjusted P value
Age 16 - 30 vs age 31 - 45 years	0.245	-0.04 to 0.56	No	ns	0.1102
Age 16 - 30 vs age 46 - 60 years	0.535	0.24 to 0.82	Yes	***	0.0001
Age 16 - 30 vs age 61 - 75 years	0.96	0.67 to 1.24	Yes	****	0.0001

The above Tables 5, 6, 7 and 8 showed that the splenic length decreased with increasing age in both males and females. This study shows that in both males and females splenic length was not significantly changed up to age of 45 years and after that age the splenic length decreased at a slow rate. The splenic length was significantly decreased after age of 60.

Table 9: Showing ANOVA test for splenic thickness for males of different age groups

ANOVA table	SS	DF	MS	F(DFn Dfd)	P value
Between column	18.06	3	6.02	F(2.2,41.97) = 30.13	P <0.001
Within column	3.83	19	0.201		P = 0.4659
Total	33.28	79			

Table 10: Showing Dunnett’s multiple comparison tests for splenic thickness of males for different age groups

Dunnett’s multiple comparisons test	Mean Diff	95.00% Cl of diff	Significant	Summary	Adjusted P value
Age 16 - 30 vs age 31 - 45 years	0.075	-0.26 to 0.41	No	ns	0.912
Age 16 - 30 vs age 46 - 60 years	0.695	0.35 to 1.03	Yes	***	0.0001
Age 16 - 30 vs age 61 - 75 years	1.16	0.82 to 1.49	Yes	****	0.0001

Table 11: Showing ANOVA test for splenic thickness for females of different age groups

ANOVA table	SS	DF	MS	F(DFn Dfd)	P value
Between column	29.81	3	9.938	F(3,156) = 63.13	P <0.001
Within column	24.56	156	0.1574		
Total	54.37	159			

Table 12: Showing Dunnett’s multiple comparison test for splenic thickness of females for different age groups

Dunnett’s multiple comparisons test	Mean Diff	95.00% Cl of diff	Significant	Summary	Adjusted P value
Age 16 - 30 vs age 31 - 45 years	0.15	-0.06 to 0.36	No	ns	0.2206
Age 16 - 30 vs age 46 - 60 years	0.68	0.46 to 0.89	Yes	***	0.0001
Age 16 - 30 vs age 61 - 75 years	1.08	0.87 to 1.29	Yes	****	0.0001

The above Table 9, 10, 11 and 12 showed that in both males and females splenic thickness was not significantly changed up to age of 45 years and after that age the thickness of spleen were decreased at slow rate. Likewise, the splenic thickness was decreased significantly after age of 60 years.

Table 13: Unpaired T test for splenic length for both males and females

Unpaired t-test	
P value	<0.0001
P value summary	****
Significantly different (P<0.05)?	Yes
One - or two - tailed P value	Two - tailed
T, df	t = 5.113, df = 318

The above Table 13 showed that splenic length was greater in males than those in females in each age group of this study.

Table 14: Unpaired t-test for splenic thickness for both males and females

Unpaired t-test	
P value	<0.0001
P value summary	****
Significantly different (P<0.05)?	Yes
One - or two - tailed P value	Two - tailed
T, df	t = 1.1397, df = 318

The above Table 14 showed that splenic thickness was greater in males than those in females in each age group of this study.

DISCUSSION

Splenomegaly is a well-known manifestation of several diseases that may involve the liver, immune system, and hematopoietic system. Accurate noninvasive assessment of splenic volume is used in the clinical treatment of patients with these diseases. Assessment of splenic size by physical examination is subjective and known to be inaccurate⁶⁻⁹; therefore, evaluation with radiologic imaging is common. Several prior studies have sought to develop the standards for measuring the splenic size such as CT scan, scintigraphy, MRI and sonography. Clinicians at our Institution commonly request sonography to evaluate patients for clinically suspected splenomegaly and because sonography is a rapid, accurate, easily operable, fast assessment and cost effective for evaluation of the spleen dimensions with no radiation exposure.

In the present study it was observed that splenic length decreased with age in both males and females. This study revealed that in both males and females splenic length and thickness not significantly changed up to age of 45 years and after that age the splenic length and thickness were decreased at a slow rate. The splenic length and thickness were significantly decreased after age of 60 years. The findings of this study were in agreement with the findings of Loftus and Metreweli (1997)¹⁰ who 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. Similarly other studies also demonstrated that the splenic length decreased at a slower rate up to the age of 50 years, after that it decreased abruptly^{5,11}.

This study also demonstrated that the splenic length and thickness of males were greater than those in females in each age group of this study. In present study, the men spleen length were more (10.07 ±0.7 cm, 10.1 ±0.54 cm, 9.5 ±0.7cm and 9.0 ±0.43 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively) than in females (9.83 ±0.53 cm, 9.58 ±0.58cm, 9.2 ±0.64 cm and 8.8 ±0.36 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively). Similarly the men spleen thickness were more (4.1 ±0.5 cm, 4.05 ±0.58 cm, 3.43 ±0.38 cm and 3.0 ±0.36 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively) than in females (4.06 ±0.47cm, 3.78 ±0.48 cm, 3.38 ±0.35 cm and 2.29

± 0.23 cm for age group of 16 - 30, 31 - 45, 46 - 60 and 61 - 75 years respectively). Thus significant difference between male and female splenic dimension was found for each age group chosen (P <0.05). The findings of this study were supported by other similar studies conducted in different parts of world^{12,13} who demonstrated that the spleen length was greater in males than in females by 0.2 cm and this difference was found to be significant. Perhaps this increased values in males than in females were due to general development of the organs in males or the differences in weight, height, body surface area and genetic factors^{5,14}.

In present study all spleen lengths were below 11 cm. Similar findings were observed by Frank K *et al* who demonstrated that 95% of the cases spleen length was less than 11 cm¹⁵. Likewise in another study it was revealed that the splenic length was below 12.80 cm in 95% subjects¹⁵. However, the splenic length was found below 8.7 cm with mean and SD, 5.5 ±1.4 in study conducted by Niederau C *et al*¹⁶. Racial differences in splenic length could result in inaccurate interpretation of the splenic size as noted by Lotus *et al*. The observation by Loftus *et al*, suggested that a population specific splenic normogram would provide more accurate standards¹⁷.

CONCLUSION

The human spleen is an organ demanding constant attention from the anatomical, immunological and clinical point of view. Clinically spleen is an important organ as it becomes enlarged and reduced in many diseases. The values obtained in this study can be used as the standard reference for normal dimension of spleen in the Nepalese adults for Ultrasonographic measurement of the spleen size. Indeed the established normogram can be more reliably used as both a complementary modality to clinical evaluation and as a more sensitive means of evaluating and screening patients for splenic disorders for any pathological enlargement or reduction of size in clinical practice in Nepalese population.

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