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Research Article

Ultrasound Criteria of Splenomegaly

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Abstract

The aim of the study was to compare the linear measurements of the spleen (length, width, thickness), volume, mass and spleen mass coefficient in volunteers and correlate these values with age, anthropometric data, anamnesis and race. There were 93 volunteers involved to investigation. Ultrasound examination of the spleen was performed on the SonoScape S6 ultrasound scanner by a curvilinear transducer with a frequency of 3 MHz to 5.4 MHz. The size of the organ was measured in B-mode. We got a conclusion that morphometric parameters of the spleen depend on the ethnic origin of the subject. Persons with increased spleen mass coefficient had a history of chronic or recently suffered acute infectious disease. Spleen mass coefficient can be used in the control of infectious diseases convalescence.

Keywords: Spleen; Ultrasound; Splenomegaly; Computed tomography

Introduction

The spleen is the largest secondary lymphoid organ. Spleen size varies widely depending on the functional activity and reflects the general condition of the body. Thus, the size of the spleen varies with liver diseases, diseases of the blood system, infectious and immune processes [1]. In all these cases, there is an increase in the size of the spleen that is called "Splenomegaly" [2].

During physical examination, splenomegaly can be detected by palpation. However, if the spleen is not palpable, this does not always mean that it is not altered [3]. Currently, it is common practice to assess splenomegaly based on the results of changes in the volume of the spleen, which can be diagnosed by various methods, such as radiography, scintigraphy, computed tomography, magnetic resonance imaging and ultrasound [3]. The latter refers to a non-invasive, approachable and quite informative imaging method without the risk of exposure to ionizing radiation on the patient, and there are currently a sufficient number of publications for this method of studying the spleen [3].

Attempts to establish the normal limits of the spleen size on the results of ultrasound examination deserve special attention. Thus, it is shown that linear spleen measurements (length, width, thickness), and the spleen volume calculated on the basis of them may depend on age [4], sex [3,5-7], height [1,4,7], body mass [4,7]. Researchers from Turkey point to the absence of a statistically significant correlation of spleen length, height, weight and surface area [8]. In Africans, a relationship was found between spleen volume and spleen length and sex, in men, these indexes were greater than in women, while a correlation between spleen volume and age, body weight, height, and body mass index was not found [6]. Researchers from Jordan claim that the size of the spleen depends on sex, but does not depend on the patient's age [3]. In Nigeria, a comparison of the parameters of the average size of the spleen in men and women showed a statistically significant difference. In particular, there was also no statistically significant correlation of spleen measurements with age in both sexes [5]. Scientists from Germany studied the size of the spleen and the dependence of size on height and sex. The study revealed that the length of the spleen is directly dependent on height and sex, in men with high growth the length of the spleen is longer than in women [5]. Ultrasound examination of the normal length and volume of the spleen in Caucasian children showed a significant correlation between the length and volume of the spleen by age, height and weight [9].

The concept of "Spleen Mass Coefficient (SMC)" was introduced to objectively interpret the volume of the spleen. When SMC is calculating, the patient's body mass indexes are leveled [10,11]. The authors point that the spleen mass coefficient 2.3 to 3.9 is normal. It is possible to say about splenomegaly when SMC is more than 4.0.

The aim of the study was to compare the linear measurements of the spleen (length, width, thickness), volume, mass and spleen mass coefficient in volunteers and correlate these values with age, anthropometric data, anamnesis and race.

Materials and Methods

Volunteers

The study was performed from March to June 2019 and involved 93 volunteers (students of Immanuel Kant Baltic Federal University, Kaliningrad, Russia). Two subgroups were formed. The first subgroup included 76 Europeans (12 males and 64 females), spleen size in this subgroup was compared with age, sex and anthropometric data of volunteers. The second subgroup included 14 Europeans (3 males and 11 females) and 17 Hindus (10 males and 7 females). In this subgroup spleen size parameters were compared with race of each person.

The participants signed an informed consent to investigation. The consent is made in accordance with the Federal Law of November 21,

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2011 No. 323-FZ "About bases of protection of public health in the Russian Federation". All participants also completed a questionnaire, which included data on age, height, weight, and a history of illnesses.

Measurements and formulas

Ultrasound examination of the spleen was performed on the SonoScape S6 ultrasound scanner by a curvilinear transducer with a frequency of 3 MHz to 5.4 MHz. The size of the organ was measured in B-mode, in the supine and right lateral decubitus position (Figure 1 and 2).

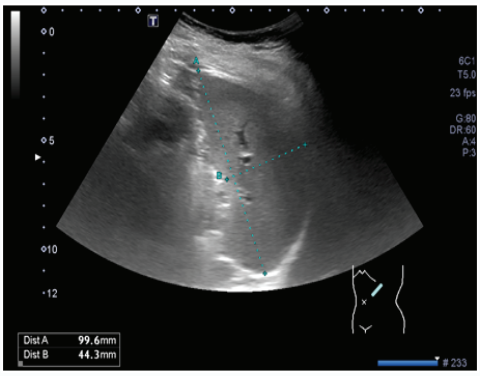

Figure 1: Ultrasound spleen morphometry - length (A), thickness (B).

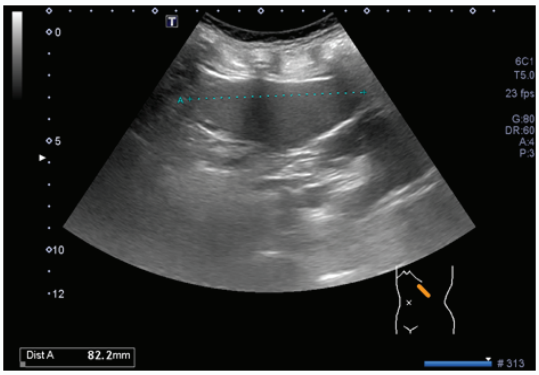

Figure 2: Ultrasound spleen morphometry - width (A).

Spleen length (in centimeters) was determined as the maximum distance between the most medial and most lateral points in the longitudinal plane. Spleen width, defined as the maximum anteroposterior size, was measured in the transverse plane. Spleen thickness was determined as the mediolateral distance from the spleen hilum to its capsule, measured in longitudinal plane [3]. The study began with intercostal spaces adjacent to the tenth rib, along the posterior axillary line with the longitudinal position of the transducer. In this position, the maximum length and thickness of the spleen were measured. The spleen hilum was evaluated by visualization of spleen vessels. When the transducer was rotated 90° from the plane of the maximum length of the spleen, a transverse image of the organ was obtained to measure the anteroposterior diameter (width) of the spleen. To improve the visibility of the spleen, patients were asked to take respiratory excursions.

US exam evaluated the echogenicity, echotexture, organ homogeneity, the presence or absence of an accessory spleen and the hilum of the spleen. To estimate the volume of the spleen, the standard formula was used to calculate the volume of the semi ellipsoid [3-6,8,12].

$V\ (cm^3)$ = length (cm) × width (cm) × thickness (cm) × 0.523

To determine the mass of the spleen, $m= 0.34l^2t$

Where l= Length of the spleen; t= Thickness of the spleen [10,11].

To calculate the Spleen Mass Coefficient, SMC= Spleen mass (g) × 1000 / body weight (g)

The obtained data were analyzed using standard statistical techniques with the calculation of average values, the calculation of the Pearson correlation coefficient [3,5,10,11]. To determine the significance of factors affecting the volume of the spleen, Fisher's criterion was used. To determine the statistical significance of the differences, non-parametric Mann-Whitney methods were used. Results were considered statistically significant at $p<0.05$.

Results

The spleen ultrasound of the first group revealed that in all volunteers the spleen has a smooth margins, uniform echotexture, and the echogenicity of spleen is isoechoic to the liver [13]. Accessory spleen was found in six volunteers.

The average age of volunteers was 23.1 ± 2.77 years (from 18 to 31 years); the average body weight of the group members was 62.4 ± 12.3 (from 43 kg to 98 kg), the average height of participants of Slavic origin was 168 ± 9.2 (from 153 cm to 193 cm), the average body surface area was 1.7 ± 0.2 (from 1.38 m^2 to 2.7 m^2). The average morphometric parameters of the spleen in Russian volunteers were as follows: the length of the organ was 10.1 ± 1.5 (from 7.6 cm to 13.8 cm); width 6.1 ± 1.8 (from 8.1 cm to 12.7 cm); thickness 4.2 ± 0.83 (from 2.3 cm to 6 cm). The average organ volume for the first group was 141.15 ± 72.4 (from 33 cm^3 to 395 cm^3). The average organ weight of the volunteers was 151 ± 66 (from 48 g to 362 g). The average Spleen Mass Coefficient (SMC) was 2.8 ± 1.2 (from 0.9 to 6.7).

We demonstrate a Table 1 to see the size distribution of the spleen depending on height and sex, so that its data can be compared with the results of previous studies, data in brackets show dispersion of values from the minimum to maximum [5].

Table 1: Values of the growth and volume of the spleen, depending on the height and sex of the subjects.

Values of the growth (cm)			Volume of the spleen (cm)	
	Women	Men	Females	Males
150 cm to154 cm	3	-	11 (9.9-11.9)	-
155 cm to 159 cm	7	1	9.6 (7.6-11.7)	8.8
160 cm to 164 cm	22		9.8 (7.8-13.8)	-
165 cm to 169 cm	14	-	9.5 (8.5-11)	-
170 cm to 174 cm	13	1	9.8 (7.7-13.8)	10.6
175 cm to 179 cm	3	5	10.6 (9.3-11.7)	11.3(10.7-11.7)
180 cm to 184 cm	1	1	10.5	8.8
185 cm to 189 cm	-	3	-	12 (10.1-13.1)
190 cm to 194 cm	-	2	-	9.9 (8.7-11.1)
	Women	Men	Volume of the spleen (cm^3)	
150 cm to 154 cm	3	-	199 (146-251)	-
155 cm to 159 cm	7	1	92.5 (41-185)	101.1
160 cm to 164 cm	22	-	128 (33-275)	-
165 cm to 169 cm	14	-	133 (51.3-201.4)	-
170 cm to 174 cm	13	1	144 (48-205)	183
175 cm to 179 cm	3	5	158 (72-245)	217(175-341)
180 cm to 184 cm	1	1	79.1	124
185 cm to 189 cm	-	3	-	252(151-395)
190 cm to 194 cm	-	2	-	102.5(55-150)

Comparing the obtained data with the results of other authors, we can state that our results coincide with the results of ultrasound spleen volume calculation of Germans, despite the fact that our sample was small.

The correlation coefficient between the length of the spleen and its volume showed a strong positive relationship ($r=0.729$, $P \leq 0.05$). A weak correlation was found between the height, weight and length of the spleen and ($r=0.213$ and $r=0.200$, respectively). The data we obtained correlate well with those for Europeans (Germans) [5].

We also have not found a correlation between the age of the subjects and the length of the spleen, which is partially consistent with the literature data. Due to the insufficient sample size, it was not possible to carry out a correlation analysis between the value of the volume of the spleen and the gender of the volunteers.

Discussion

The spleen mass coefficient levels anthropometric features of a person. We consider the spleen mass coefficient exceeding 4.0 indicates splenomegaly [10,11]. The median spleen mass coefficient in volunteers of the first group was 2.8 (from 0.9 to 6.7). Among them, in 65 volunteers (85.5%) spleen mass coefficient did not exceed 4.0. In 11 volunteers (14.5%) spleen mass coefficient was greater than 4.0. Among of these 11, four persons indicated a history of chronic diseases (chronic otitis media, tonsillitis), five persons indicated recently (within two weeks prior to the study) suffering infectious disease of the upper respiratory tract. A person with the highest SMC have suffered in an amnesia unilateral focal pneumonia a year before the study. Therefore our study to some extent confirms the significance of the spleen size as a marker of an infectious disease [14-16].

It's interesting that from 76 volunteers in 9.2% (7 persons) an accentuated spleen hilum was revealed, while the spleen mass coefficient among them was ranged from 2.0 to 3.3. Among of these 7 persons one person informed about a history of chronic disease (chronic pharyngitis) and three persons informed about acute viral infection suffered within two weeks prior to the examination.

The second group of volunteers consisted of two subgroups, one of which included volunteers from the first subgroup (Europeans), and the second-Indian volunteers. All the anthropometric and age characteristics of these persons were comparable to each other. Thus, we obtained practically homogeneous groups by age, height and body weight in order to test the hypothesis that ethnicity is a factor affecting the size of the spleen. Comparative characteristics of subgroups are presented in Table 2, data in brackets show dispersion of values from the minimum to maximum.

Table 2: Comparative characteristics of the parameters of the spleen and anthropometric data of Europeans and Indians.

Parameters	Europeans	Hindus
Sex	Male-3 Female-11	Male-10 Female-7
Age, years	19.1 (19-20)	19.7 (19-21)
Body mass, kg	58.3 (38-80)	58.7 (40-80)
Growth, cm	169 (150-186)	165.8 (150-185)
Length of the spleen, cm	10.50 (8.3-13.5)	9.32 (7.4-11.2)
Spleenwidth, cm	7.5 (4.0-9.6)	5.3 (3.1-7.7)
Spleen thickness, cm	4.43 (2.5-5.9)	4.00 (3.2-5.1)
Bodysurfacearea, m^2	1.65 (1.25-1.95)	1.64 (1.38-1.63)
Spleen volume, cm^3	186.45 (63.00-309.10)	102.90 (45.50-149.00)
Mass of a spleen, g	173.0 (59.5-353.0)	119.1 (60.0-156.0)
Spleen mass coefficient	3.20 (1.10-6.50)	1.50 (0.75-1.95)

Spleen ultrasound in each individuals of the second group revealed that in all volunteers the spleen had a smooth margins, homogeneous echotexture, and echogenicity of the spleen was isoechoic to the liver. Accessory spleen was found in one volunteer from a subgroup of Europeans; among the Hindus, such variant of the norm were not found.

The results of ultrasound examination of the spleen in second group are presented in Table 2. This table shows that the median of spleen length and width (as well as minimum and maximum values) is less among the Indians, and it's especially concerned for the spleen width. The difference in mean values of these parameters between European and Hindu volunteers was statistically significant ($p \leq 0.05$). Accordingly, the significance in differences for the derivate parameters was observed for volume of the spleen, the mass of the spleen and the spleen mass coefficient. The Fisher test we used confirmed the null hypothesis that ethnicity was a factor determining the mean values of spleen length and width.

It should be noted that among the volunteers of the Indian group, the spleen mass coefficient was not greater than 1.95.At the same time in European group 4 volunteers had spleen mass coefficient ranged from 4 to 6.5, that corresponds to splenomegaly [10,11]. Among these four persons, two of them had a history of an infectious disease of the upper respiratory tract within two weeks prior to the study, and one person pointed to acute pneumonia suffered a year ago [17-18].

It's interesting that in 1 volunteer from European group had the accentuated hilum of the spleen, whereas spleen mass coefficient was 1.1. In the Hindus, the accentuated hilum was found in three persons, while their spleen mass coefficient was ranged from 1.5 to 1.9, and two out of three persons informed about acute viral infection within two weeks prior to the study. That's why we propose the presence of accentuated hilum of the spleen depends on the presence in the history of an infectious disease and is correlated with an increase of spleen mass coefficient [19].

Conclusion

The difference we found in spleen size among European and Indian volunteers raises the question of what criteria should be used in determining splenomegaly. Obviously, the criteria for splenomegaly applied for European volunteers are not suitable for Indian volunteers due to their anatomical features. Probably, as a criterion for splenomegaly, we should take some new values, for example, the diameter of spleen vessels, the ratio of spleen length to the size of the nearby kidney, and others.

- Our study confirms the data given for the European population (Germans), so we can assume that for the inhabitants of Eastern Europe it is possible to apply the criteria for the size, developed in Western Europe.
- Our study showed that the morphometric parameters of the spleen, its volume and mass ratio depend on the ethnic origin of the subject. This allows us to raise the question of how to regulate the standards for the size of the spleen, obtained by ultrasound diagnostics.
- Our data show the relationship between an increase in the spleen mass coefficient and the presence of a history of chronic or recently suffered acute infectious disease, which is of interest both in terms of retrospective diagnosis and in the control of infectious diseases convalescence. In addition, for the same

purpose, we can recommend to pay attention to the accentuated hilum of the spleen during ultrasound exam.

References

1. Reinert CP, Hinterleitner C, Fritz J, Nikolaou K, Horger M. Diagnosis of diffuse spleen involvement in haematological malignancies using a spleen-to-liver attenuation ratio on contrast-enhanced CT images. Eur Radiol. 2019;29(1):450-7.
2. Chapman J, Azevedo AM. Splenomegaly. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019.
3. Badran DH, Kalbouneh HM, Al-Hadidi MT, Shatarat AT, Tarawneh ES, Hadidy AM, et al. Ultrasonographic assessment of splenic volume and its correlation with body parameters in a Jordanian population. Saudi Med J. 2015;36(8):967-72.
4. Nemati M, Hajalioghli P, Jahed S, Behzadmehr R, Rafeey M, Fouladi DF. Normal Values of Spleen Length and Volume: An Ultrasonographic Study in Children. Ultrasound Med Biol. 2016;42(8):1771-8.
5. Chow KU, Luxembourg, Seifried E, Bonig H. Spleen size is significantly influenced by Body height and sex: Establishment of normal values for spleen size at US a cohort of 1200 healthy individuals. Radiology. 2016;279(1):306-13.
6. Mustapha Z, Tahir A, Tukur M, Bukar M, Lee WK. Sonographic determination of normal spleen size in an adult African population. Eur J Radiol. 2010;75(1): e133-5.
7. Ehimwenma O, Tagbo MT. Determination of normal dimension of the spleen by ultrasound in an endemic tropical environment. Niger Med J. 2011;52(3):198-203.
8. Serter S, Ceylan C, Tunçyürek Ö, Örgüç Ş, Pabuçcu Y. Sonographic evaluation of spleen size and prevalence of accessory spleen in a healthy male Turkish population. Turk J Haematol. 2010;27(1):25-8.
9. Nemati M, Hajalioghli P, Jahed S, Behzadmehr R, Rafeey M, Fouladi DF. Normal Values of Spleen Length and Volume: An Ultrasonographic Study in Children. Ultrasound Med Biol. 2016;42(8):1771-8.
10. Vozgoment OV, Pykov MI, Zaitseva NV. Ultrasound Assessment of Spleen Size in Children. New Approaches. Ultrasound and Functional Diagnostics. 2013.
11. Perepelitsa S, Vozgoment O. Spleen Mass Coefficient: a New Marker of Intrauterine Infection. Russian J Immunol. 2018;12(21):722-4.
12. Pelizzo G, Guazzotti M, Klersy C, Nakib G, Costanzo F, Andreatta E, et al. Spleen size evaluation in children: Time to define splenomegaly for pediatric surgeons and pediatricians. PLoS One. 2018;13(8): e0202741.
13. Andrews MW. Ultrasound of spleen. World J Surg. 2000;24(2):183-7.
14. You JH, Lv GR, Liu XL, He SZ. Reference ranges of fetal spleen biometric parameters and volume assessed by three-dimensional ultrasound and their applicability in spleen malformations. Prenat Diagn. 2014;34(12):1189-97.
15. Tyuryumina EE, Chizhova EA. Ultrasound Diagnosis and Minimally Invasive Treatment of Posttraumatic Hematomas of the Spleen. Acta Biomedica Scientifica. 2018;3(6):130-6.
16. Vetsheva NN, Fisenko EP, Stepanova YA, Kamalov JR, Timina IE, Kiseleva TN, et al. Contrast Enhanced Ultrasound: Terminology, Technical and Methodological Aspects. MedicalVisualization. 2016;4:132-140.
17. Goher A, MilyushinaYa A. Imaging of Hamartoma. Russian Electronic Journal of Radiology.
18. Sumenko VV, Vozgoment OV, Pykov MI. Standard ehografichesky indicators of the spleen at healthy children of the Orenburg region and factors influencing them. Children's Hospital. 2013.
19. Loftus WK, Metreweli C. Ultrasound assessment of mild splenomegaly: spleen/kidney ratio. Pediatr Radiol. 1998;28(2):98-100.