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Sonographic Evaluation of Liver and Spleen Size in School-Age Children

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Abstract : The purpose of this study was to determine normal liver and spleen size variations in school-age children by US. Sonographic measurements were taken with an age and sex stratified random sample of 358 healthy children (188 boys, 170 girls) between the ages of 7 and 12 years. The weight and height of the children were assessed and then the body surface area (BSA) of each child was calculated. The size of the liver was measured in two different planes: the subcostal sagittal (L1), and subcostal semiaxial (L2). Spleen size was measured through a coronal view that included the hilum (S1) and the longest longitudinal length (S2). Although there was no significant correlation between the age, weight and BSA

of the children and liver and spleen size, there was a significant correlation between L1 and BSA, and between S2 and BSA. There was a correlation between L1 and S2 when the liver and spleen measurements were compared. In the girls, a significant increase was found in the size of liver and spleen between the age of 8 and 9. Spleen size decreased significantly in girls after the age of 10. Among the school-aged children there were no statistically significant differences in the size of the liver and spleen. We recommend the use of L1 and S2 in liver and spleen measurements in comparison with BSA.

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Key Words: Liver size, spleen size, ultrasound, pediatrics

Introduction

Ultrasound (US) is an extremely important imaging method in the evaluation of the liver and spleen in children due to the fact that it is easy to use, provides real-time images, does not require anaesthesia and does not utilise ionising radiation. In most cases, determination of hepatomegaly or splenomegaly is necessary and generally sonography is performed for this purpose. In cases of gross enlargement of the liver and spleen, confirmation of hepatosplenomegaly is easy. In cases where there is only mild enlargement, making decisions about the size can be difficult. It is very important to have a set of standard normal sonographic measurement values, showing upper and lower limits.

In the literature, there are few studies concerning the sonographic determination of liver and spleen size. In the present study, our aim was to evaluate liver and spleen size variations by comparing parameters such as age, weight, height and BSA in school-age children.

Materials and Methods

An age and sex stratified random sample of 784 boys and girls between the ages of 7 and 12 (mean age 9.6 ± 1.3), consisting of primary school students in four different regions of Malatya, Turkey received the offer of a general health examination at the Turgut Ozal Medical Center. All parents received a standard letter describing the purpose of the examination. The examinations were performed between September 1996 and March 1997. Of the 784 children, 562 (72%) attended the general health examination. All of the 562 children were subjected to abdominal ultrasound examination after the consent of the parents had been received. 204 children were excluded from the study for the following reasons; increased liver echogenicity (41 cases), jaundice history (94 cases), brucella history (1 case) and other pathologies (68 cases). All of the participants came to the hospital after fasting overnight. They underwent complete physical examination and their weight and height were measured. The total body area of each child was calculated using the following formula:

$$\text{Body surface area} = \sqrt{\frac{\text{weight} \times \text{height}}{3600}} \quad (1).$$

Sonography was performed with Scanner 250 (Pie Medical, Holland) using a 3.5 MHz curved array sector probe. All measurements were taken by three different radiologist while each child lying supine. Although the supine position was sufficient for measurement, in some cases elevation of the examined side was necessary. Ultrasonographic measurements of the liver and spleen were obtained for 358 (170 girls, 188 boys) healthy children in various planes. Liver size measurements were obtained in two different planes; 1) the subcostal sagittal plane (L1) in which the greatest longitudinal length of the right kidney was seen, and 2) the subcostal semiaxial plane (L2) in which there was the greatest length between the lower border of the liver and the diaphragm. For spleen size measurements, the width of the spleen in the coronal plane at the hilum (S1) and the longest longitudinal length from the dome to the tip of the spleen (S2) were used.

The values for the liver and spleen measurements obtained in two different planes, were grouped according to age and the mean values for each age group were calculated. The relationships between the ultrasonographic liver and spleen values, and the age, weight, height and BSA of the children were investigated.

Systat 5.02 for Windows (Systat, Inc. Evanston, IL, USA) was used in computing statistics. The statistical evaluations of the data were performed by one-way analysis of variance (Anova) for comparison between the means, by unpaired and paired t test, by chi-square, by Pearson's correlation or linear regression analysis. Values were expressed as the means±SD. P values ≤0.05 were considered statistically significant.

Results

There was no statistically significant correlation between the age, weight, height and BSA of the children and the ultrasonographic measurement of the liver and spleen size. A statistically significant difference was seen between girls and boys in S2 measurements when all cases were evaluated (p<0.001; 84.5±10.9 mm and 88.3±10.4 mm respectively). When the ultrasound measurement values for girls and boys were compared separately, no statistically significant difference was determined in boys between age and measurement values. When ultrasonographic measurement values according to gender were compared, it was found that S2 values were significantly lower in girls than in boys. This difference was especially significant between the ages of 11 (p<0.005) and 12 (p<0.001). S1 values in girls aged 12 years were statistically lower than they were in boys (p<0.005, 33.6±3.8 for girls and 36.8±5.3 for boys). There was no statistically significant difference in L1 and L2 values between the genders. (Table).

When the age, weight and BSA values of the children were compared to the ultrasonographic measurement values for liver and spleen size, we could not find a statistically significant correlation between weight and height, and liver and spleen measurement values. The most significant correlation was found to be between S2 and BSA (r=0.47, p<0.001), and L1 and BSA (r=0.44, p<0.002) (Figures 1 and 2). There was a significant correlation between L1 and S2 when the liver and spleen measurements were compared (Figure 3). In the girls a significant increase was found in the size of the liver and spleen between the ages of 8 and 9 years. The spleen size decreased significantly in girls after the age of 10 (Figure 4).

Table : Median splenic and liver length in 358 boys and girls according to age group

Age		7	8	9	10	11	12	Total
S2	boy (n: 188)	82.5	82.6	88.4	91.4	93.3	94.7	88.3
	girl (n: 170)	79.5	79.7	87.3	89.0	84.7#	83.5*	84.5*
L1	boy (n:188)	118.6	119.6	119.3	124.4	124.7	127.4	121.8
	girl (n:170)	113.3	114.6	123.4	124.2	120.6	121.0	119.9

*student's t test p<0.001

#student's t test p<0.005

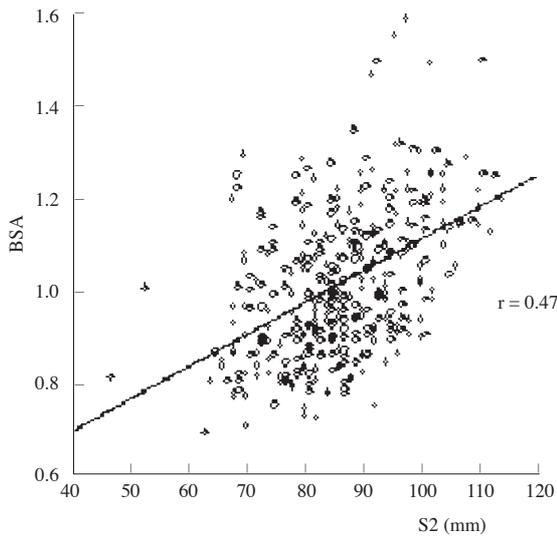


Figure 1. Spleen length (S2: mm) plotted against body surface area (BSA: m²) shows a roughly linear correlation for the group of 358 children.

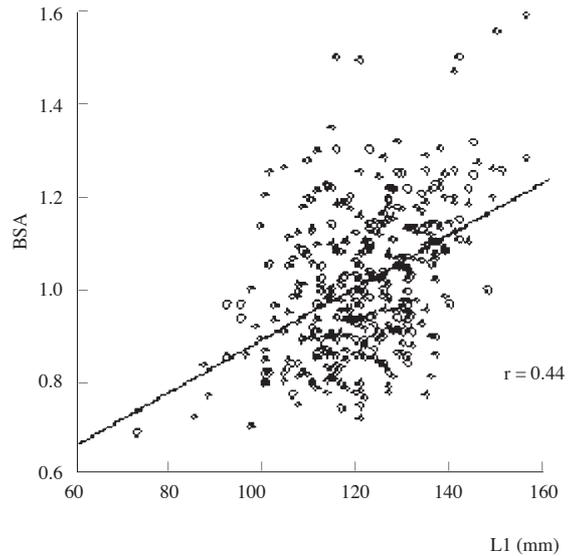


Figure 2. Liver length (L1: mm) plotted against body surface area (BSA) shows a roughly linear correlation for the group of 358 children.

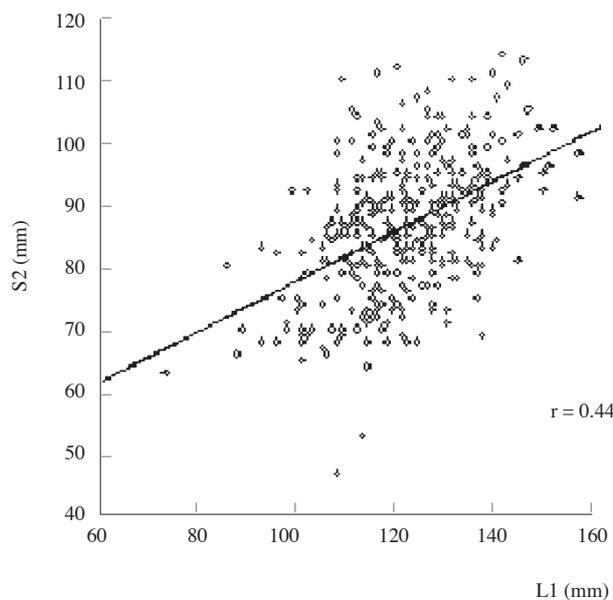


Figure 3. Scatter plot of splenic length (S2: mm) vs liver length with regression line superimposed.

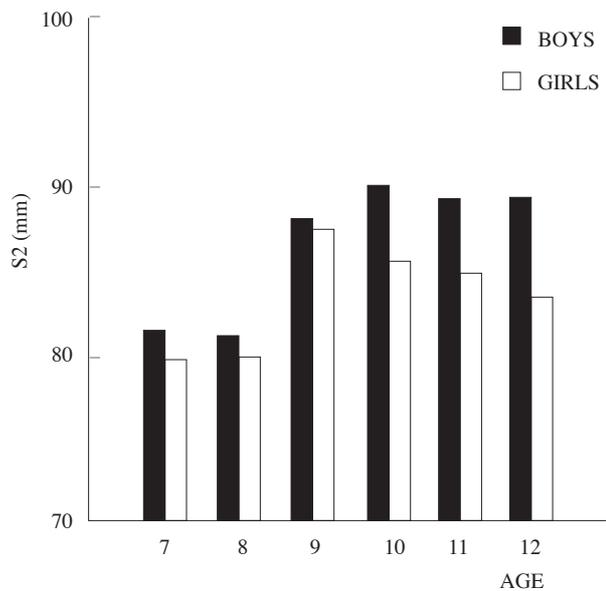


Figure 4. Bar graph shows the distribution of spleen length (S2: mm) according to age group. The spleen size was significantly decreased in girls after the age of 10.

Discussion

Various methods are defined for the evaluation of liver and spleen size in the literature (2, 3, 4, 5). However, sonography is a simple, practical, low-cost and accurate method. In the evaluation of liver and spleen size, different techniques have been reported. Some of

these have been used to measure serial sections of the spleen and liver by planimetry, and calculate the volume by adding the values for each section (2, 6). However, these techniques are cumbersome and not widespread (5). Judging the size using only the naked eye has been stated as being the most commonly used method.

However, this method requires more experience and is relatively inaccurate. As with all other structures in the body, it is helpful to have measurements that establish the upper limits of normal. The wide range of normal liver and spleen sizes combined with a complex three-dimensional shape makes it particularly difficult to establish a normal range of sonographic measurements. These measurements may be useful for borderline cases (7). In most patients, measurement of the liver length suffices when measuring liver size. In heavy or asthenic individuals, the anteroposterior diameter should be added to avoid underestimations and overestimations. Rosenberg et al. used a coronal view that included the hilum and the greatest longitudinal distance for sonographic evaluation of spleen size in infants and children, and they recommended the use of this method (8).

In the literature, normal liver and spleen sizes in different age groups have been reported. DeLand (9) stated that the size of the spleen in 440 adult autopsy specimen showed variation according to sex and age. He reported that spleen size in females was smaller than males in all age groups. Niederau et al. (10), in their sonographic study, which was carried out on adults, found that spleen size decreased with increasing age. Again, in the same study, the liver was measured in terms of longitudinal and anteroposterior diameter in both the mid-clavicular line and midline. The findings were correlated with sex, age, height, weight and BSA. It was found that liver size increased with height and BSA and decreased with age.

Markisz et al. (5), in their sulfur colloid scintigraphy study carried out to measure splenic volume, found the linear correlation with age and weight to be poor. Rosenberg et al. (8), in their sonographic study of 230 cases in the first and second decades of life, evaluated only one dimension of the spleen and found a rough logarithmic correlation between spleen size and age. Again, it was stated that there is a correlation between the size of the spleen and height and weight. They reported that the difference between the two sexes emerges after 15 years and that the difference is related to the differences in body measurements. However, the cause of these differences may be the wide range of age groups. In our study, we grouped the children according to one-year intervals. In addition, we did not find a significant relation between body measurements and age group and the size of the liver and spleen. There was only a rough correlation between the BSA of girls and S2. Nevertheless, a significant decrease in the spleen size of girls after the age of 10 was seen and this decrease had no correlation with body measurements. We could not explain this decrease.

We determined that in the ultrasonographic evaluation of liver and spleen in two different planes, there was a linear correlation between S2 and L1. Again, L1 and S2 had a better correlation with BSA when compared to the other two methods of measurement. For the sonographic evaluation of liver and spleen size in school-age children, we recommend the use of L1 and S2 according to BSA rather than age group.

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