Original Article

Ultrasound Measurement of Liver Longitudinal Length in a North Anatolian Population: A Community-based Study

Zafer Özmen, Fatma Aktaş, Zeliha Cansel Özmen[1], Eda Almus[2], Osman Demir[3]

Departments of Radiology, [1]Biochemistry and [3]Statistic, Faculty of Medical School, Gaziosmanpaşa University, Tokat, [2]Department of Radiology, Osmaniye State Hospital, Osmaniye, Turkey

ABSTRACT

Background: Liver size can be influenced by various factors, including malignant diseases, infective processes, and anthropometric variations among individuals from different geographical locations and races. Therefore, the exact definition of hepatomegaly in the ultrasonographic measurement of liver size is controversial. Moreover, the majority of studies regarding the study of liver size are not community-based. **Aims:** The aim of this study is to establish a range of normal liver sizes by ultrasonography with respect to age and sex in healthy individuals and to identify factors affecting liver size. **Study Design:** This was a prospective, community-based study. **Methods:** Liver size was measured ultrasonographically from the midclavicular line in 822 individuals, of which 49.3% (n = 405) were male and 51.7% (n = 417) were female. Following physical examination, all participants provided blood samples. Height, weight, and waist circumference were recorded. The mean liver length was calculated for males, females, and for the whole study group. It was also determined whether there was an association between liver size and age, weight, height, body mass index (BMI), body surface area, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) enzyme levels. **Results:** The mean liver length was significantly different between males (150.04 ± 14.84) and females (147.57 ± 18.32, $P = 0.034$). Weight and BMI were the most strongly associated with liver size. There was a significant difference between liver size in individuals with normal and elevated levels of AST and ALT enzymes ($P < 0.01$). **Conclusion:** In a northern Anatolian Turkish population, liver size was greater among males than females. In light of these data, we believe our study may serve as a reference source for the evaluation of liver size.

Date of Acceptance:
01-Nov-2017

Keywords: *Liver, longitudinal span, ultrasonography*

Introduction

Abdominal ultrasonography (USG) is a widely used, noninvasive, inexpensive, and convenient imaging technique. It does not emit any radiation and provides rapid results. Clinicians frequently use USG to evaluate liver size.[1] However, the exact definition of hepatomegaly in the ultrasonographic measurement of liver size remains controversial. This is because many conditions, including malignant diseases, infective processes, and anthropometric variations between individuals from different geographical regions and ethnicities can affect liver size.[2,3] For this reason, there have been many ultrasonographic measurement studies to establish the normal range of liver size in different geographical regions and populations.[2,4] In recent years, there has been an increase in the number of studies aiming to define the normal range of liver size.[5,6] These studies have often focused on sex, age, and anthropometric factors that influence liver size.[7] In Turkey, there have also been studies aiming to

Address for correspondence: Dr. Zafer Özmen, Department of Radiology, Gaziosmanpasa University, Faculty of Medical School, Tokat 60100, Turkey.
E-mail: doktor.zafer@mynet.com

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_68_17

How to cite this article: Özmen Z, Aktaş F, Özmen ZC, Almus E, Demir O. Ultrasound measurement of liver longitudinal length in a North Anatolian population: A community-based study. Niger J Clin Pract 2018;21:653-7.

ultrasonographically determine liver size in a pediatric population.[1] However, we did not encounter any adult community-based comprehensive USG studies from Turkey.

For this reason, we aimed to evaluate liver sizes in a healthy Turkish population using modern USG equipment.

Materials and Methods

In this community-based prospective study, a total of 822 individuals selected from different districts of the Tokat province of Turkey were examined with hepatobiliary USG between September 2012 and July 2013. The Family Medicine Registry System of Turkey, which encompasses all Turkish citizens, was used to select study participants. Volunteers were randomly selected from among individuals under the follow-up care of the Family Medicine Unit. Each sample group was designed based on the Turkey Statistical Institute data reflecting the population pyramid of the region (gender, age group, urban and rural settlements, etc.). Only individuals who were 20-year-old or older were included in the study. Volunteers were examined in three groups as males, females, and the whole study group. The mean and standard deviation for age, height, weight, body mass index (BMI), and body surface area (BSA) were calculated for each of the three groups. The BMI and BSA were calculated according to recommendations from the World Health Organization. Individuals were questioned as to whether they had any chronic diseases, such as hypertension, diabetes, hepatobiliary disease, myeloproliferative disease, and cardiac diseases. All individuals provided blood samples for laboratory analysis. Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels were measured with a Cobas 600 (Roche) analyzer. Serum markers of hepatitis A, B, and C were measured with a DxI 800 (Beckman Coulter) analyzer.

A hepatobiliary USG examination was performed by two radiologists with at least 10 years of experience, using a s USG device with a 3.5 MHZ pvt-375BT convex probe. USG examinations were performed following at least 8 h of fasting. The examinations were performed with individuals in the supine and right decubitus positions with their right arm over their head, during breath-holding at maximum inspiration. The liver was scanned at the intercostal and subcostal planes with a fan-like motion of the probe, which allowed evaluation of both the liver parenchyma and intrahepatic biliary ducts. In all individuals, liver size, liver contours, liver parenchymal homogeneity, and liver echogenicity were assessed.

In this study, we used the longitudinal length of the liver in the right midclavicular line (MCL) extending from the hepatic dome to the lower hepatic margin as a sonographic measurement parameter according to the method described by Borner *et al*.[8] [Figure 1]. All measurements were recorded to the nearest millimeter.

Individuals who were positive for hepatitis A, B, or C, who were younger than 20 years old, whose laboratory or anthropometric data were missing, or who had one or more of the aforementioned chronic diseases were not included in the study.

The study participants were classified into six groups according to age as follows: 20–29 years (Group 1), 30–39 years (Group 2), 40–49 years (Group 3), 50–59 years (Group 4), 60–69 years (Group 5), and 70 and older (Group 6).

The mean liver size was calculated in females, males, and for the whole study. We investigated whether there was any association between liver size and age, weight, height, BMI, BSA, and AST and ALT enzyme levels.

This study was conducted in accordance with the Guidelines of the Declaration of Helsinki and the recommendations of Good Clinical Practice. This project was approved by the local ethics committee.

Statistical analysis

Descriptive analyses were performed to provide information on the general characteristics of the study population. Continuous data were presented as mean ± standard deviation. An independent samples *t*-test or one-way ANOVA test was used to compare the continuous data between/among groups. The Chi-square test was used to compare the categorical data between/among groups. Categorical variables were presented as counts and percentages. Pearson's correlation coefficients were used for bivariate correlations. Values of $P < 0.05$ were considered statistically significant. Analyses were performed using SPSS 19 (IBM SPSS Statistics 19, SPSS Inc., an IBM Co., Somers, NY, USA).

Results

Data from 822 individuals who were examined with USG and who met all of the study inclusion criteria were evaluated. Of the participants, 49.3% (n = 405) were male and 51.7% (n = 417) were female. The ages of the individuals varied between 20 and 86 years. The anthropometric values of the participants as well as the means and standard deviations of liver size for females, males, and the whole study group are shown in Table 1.

There were significant differences between males and females regarding height, weight, BMI and

Table 1: Distribution of variables according to gender

Variables	Gender		Total	*P*
	Male (*n*=405)	Female (*n*=417)		
Age	44.88±14.03	44.49±14.61	44.68±14.32	0.724
Length (cm)	170.11±7.13	156.11±6.71	162.83±9.84	<0.001
Weight (kg)	80.91±14.04	73.5±14.93	77.06±14.97	<0.001
BMI	27.93±4.34	30.23±6.19	29.12±5.5	<0.001
BSA	1.91±0.23	1.72±0.21	1.81±0.24	<0.001
Liver size	150.04±14.84	147.57±18.32	149.8±16.73	0.034

Independent samples *t*-test was used. BMI=Body mass index; BSA=Body surface area

Table 2: Bivariate correlation of variables with liver span

Variables	Liver size (all group)	Female	Male
Age			
r	0.076	0.106	0.034
P	0.045	0.043	0.535
Weight (kg)			
r	0.413	0.437	0.401
P	<0.001	<0.001	<0.001
Length (cm)			
r	0.096	0.072	0.176
P	0.011	0.169	<0.001
BMI			
r	0.376	0.406	0.359
P	<0.001	<0.001	<0.001
BSA			
r	0.254	0.254	0.298
P	<0.001	<0.001	<0.001

BMI=Body mass index; BSA=Body surface area

BSA values ($P < 0.01$). The mean liver length of males (150.04 ± 14.84 mm) was significantly different from that of females (147.57 ± 18.32 mm, $P = 0.034$). The mean liver size in the whole study group was 149.8 ± 16.73 mm.

Correlations of liver size with age, weight, height, BMI, and BSA were evaluated separately in males, females, and in the whole study group [Table 2]. There was no significant association between liver size and age among males ($r = 0.034$, $P = 0.535$). However, there were negligible but statistically significant correlations between liver size and age in females and in the whole study group (females: $r = 0.106$, $P = 0.043$; whole study group: $r = 0.076$, $P = 0.045$). The distribution of the mean liver size in the whole study group according to age is presented in Table 3.

There were significant correlations between liver size and weight, BMI, and BSA in males, females, and in the whole study group ($P < 0.01$). The correlation between liver size and weight was moderate, but significant, in all three groups (females: $r = 0.437$, $P < 0.001$; males: $r = 0.401$, $P < 0.001$; whole study group: $r = 0.413$, $P < 0.001$). The correlation between liver size and BMI was weaker in males and the whole study group, and more moderate in females (females: $r = 0.406$, $P < 0.001$; males: $r = 0.359$, $P < 0.001$; whole study group: $r = 0.376$, $P < 0.001$). The correlation between liver size and BSA was weak, but significant, in all groups (females: $r = 0.306$, $P < 0.001$; males: $r = 0.329$, $P < 0.001$; whole study group: $r = 0.316$, $P < 0.001$). There was negligible but statistically significant association between liver size and height in males and in the whole study group (males: $r = 0.176$, $P = 0.001$; whole study group: $r = 0.096$, $P = 0.011$). The association

Table 3: Distribution of liver size according to age in the total study group

Age (year)	*n* (%)	Liver size (cm), mean±SD
20-29	107 (13)	145.15±16.22
30-39	223 (27.1)	148.42±15.71
40-49	135 (16.4)	153.49±17.36
50-59	160 (19.4)	152.71±16.61
60-69	120 (14.6)	150.86±16.43
70≥	77 (9.4)	144.53±17.61
Total	822 (100)	149.8±16.73

SD=Standard deviation

Table 4: Association between liver size and aspartate aminotransferase and alanine aminotransferase

Liver enzyms	Liver size Mean±SD	*P*
AST (IU/L)	Liver size Mean±SD	*P*
≤38	149,36±16,58	0.012
>38	159,44±20,42	
ALT (IU/L)	Liver size Mean±SD	*P*
≤35	148,85±16,38	<0.001
>35	159,55±18,45	

SD=Standart deviation; AST=Aspartate aminotransferase; ALT=Alanine aminotransferase

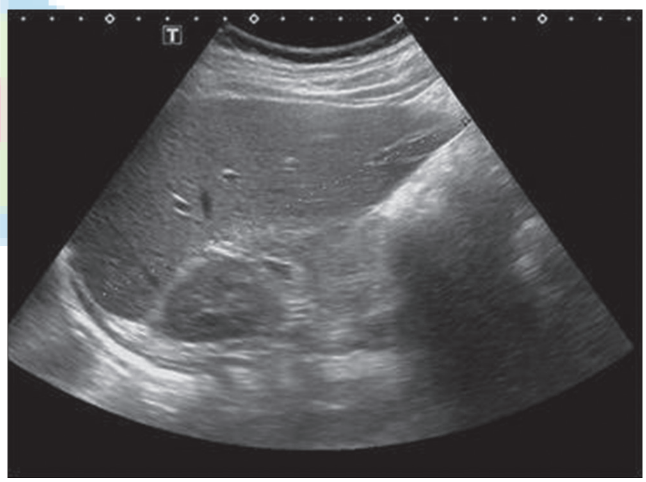

Figure 1: Sonographic measurement of liver size in the right midclavicular line extending from the hepatic dome to the lower hepatic margin

between liver size and height among females was not significant ($r = 0.072$, $P = 0.169$). Among all these parameters, the strongest association with liver size was found with weight and BMI.

Liver size was significantly different between individuals with normal and elevated levels of AST and ALT enzymes ($P < 0.01$) [Table 4]. Individuals with elevated AST and ALT levels had larger liver size in comparison to the normal group.

Discussion

USG is one of the main diagnostic methods used for the evaluation of the liver. Assessment of liver size is among the major criteria for the evaluation of this organ. In studies that aim to determine reference values for liver size, their objectiveness depends on reliable ultrasonographic measurements performed on randomized study samples. The measurement of longitudinal hepatic length at the MCL is a common technique that is used to determine liver size in routine diagnostic procedures.[8] In one autopsy study, Gosink and Leymaster[9] reported good correlation between longitudinal hepatic length (as measured by right MCL) and the actual liver size determined through autopsy. As longitudinal hepatic length measurement at the MCL is an easy and reliable technique, we used it to assess liver size in our study. Our study group was community-based and was selected by family medicine units so as to reflect the general population.

In their large-scale study, Kratzer *et al*.[10] reported the mean liver size to be 130.9 ± 1.7 mm. In another study, Patzak *et al*.[11] reported the mean liver size as 15.1 ± 1.5 cm in males, 14.9 ± 1.6 cm in females, and 15.0 ± 1.5 cm in the total population. In a similar study, Emad *et al*.[4] reported the mean liver size as 12.3 cm. In the current study, the mean liver size was 150.04 ± 14.84 mm among males, 147.57 ± 18.32 mm among females, and 149.8 ± 16.73 mm in the whole study group. Our results were quite close to those in the study by Patzak *et al*. In the current study, 28.2% of the participants had liver size above 16 cm, which is considered to be a threshold for hepatomegaly. In their study, Patzak *et al*.[11] reported the rate of hepatomegaly as 24.4%, which is very close to that found in our current study. Our study was designed to be prospective and community-based just like the study of Patzak *et al*.[11]

This may explain the similarities in our results. Differences in study design and study population may largely be responsible for the disparity between our results and those of the other mentioned studies.

Many studies, such as those conducted by Kratzer *et al*.[10] and Patzak *et al*.,[11] revealed significant correlation between liver size and sex. These studies found that males had larger liver sizes than females. Consistent with the literature, we also found that males had a larger average liver size. That the male gastrointestinal systems are larger than that of females is a well-known phenomenon that has been revealed by the studies using diagnostic imaging techniques.[12,13] That males have larger liver sizes is also supported by the results of previous autopsy studies.[4] However, there are also studies in the literature that did not find an association between liver size and sex, such as the one by Choukèr *et al*.[14]

Because there are many factors affecting liver size, such as weight, height, BMI, and regional and community-associated factors, it is only partially correct to determine whether liver size is normal by looking at a single parameter.[5,10] Some studies in the literature have found a correlation between liver size and height as well as BMI.[10,15] Among pediatric studies, Konuş *et al*.[16] revealed a significant correlation between liver size and height. Safak *et al*.[1] reported a strong correlation between liver size and weight. Toukan and Al-Adli[17] reported that weight was a major determinant for liver size. In earlier studies, Niederau *et al*.[18] and Emad *et al*.[4] found an association between liver size and weight and BSA. In the current study, weight and BMI were the most strongly correlated with liver size. Similar to the results of Niederau *et al*.[18] and Emad *et al*.,[4] we also found an association between liver size and BSA. However, in the current study, the correlation between liver size and BSA was very weak. We found a stronger correlation between liver size and BMI compared to liver size and BSA. Similar to the results of Safak *et al*.[1] and Toukan and Al-Adli,[17] in the current study, the correlation between liver size and weight was stronger than the correlations of liver size with other parameters.

Patzak *et al*. found that age does not affect liver size. However, the studies evaluating the association between liver size and age have controversial results.[10,11] In the current study, we found a negligible but statistically significant association between liver size and age in females and in the whole study group, whereas in males, there was no significant association between liver size and age.

In the current study, individuals with elevated levels of AST and ALT enzymes had significantly greater liver size compared to those with normal levels of AST and ALT. Patzak *et al*. reported an association between liver size and ALT, but not with AST.

The major limitation to our study is that it included a regional population. Therefore, our results only represent the Turkish population living in the region north of Anatolia. On the other hand, the prospective and community-based design of this study is quite important. The participants of our study were selected by family medicine units to reflect the general population in terms of age, sex, and other demographical properties.

Conclusion

The studies show that liver size is affected by many factors. The strength of the effect of these factors varies between different studies. These differences are thought to arise partially because of the study group, and partially because of factors associated with the population and geographical location that the study sample was selected from. In the current study, we found that the strongest association of liver size was with weight and BMI. In light of these data, we believe our study can be used as a reference source for the evaluation of liver size.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Safak AA, Simsek E, Bahcebasi T. Sonographic assessment of the normal limits and percentile curves of liver, spleen, and kidney dimensions in healthy school-aged children. J Ultrasound Med 2005;24:1359-64.
2. Mıttal R, Chowdhary DS. A pilot study of the normal measurements of the liver and spleen by ultrasonography in the Rajasthani Population. J Clin Diagn Res 2010;4:2733-6.
3. Joshi R, Singh A, Jajoo N, Pai M, Kalantri SP. Accuracy and reliability of palpation and percussion for detecting hepatomegaly: A rural hospital-based study. Indian J Gastroenterol 2004;23:171-4.
4. Emad ST, Azmy MH, Azmi AH, Waleed SM, Osama AS, Fadi MA, *et al*. Ultrasound measurement of liver span in Jordanian adults: A preliminary experience. Jordan Med J 2009;3:197-204.
5. Sienz M, Ignee A, Dietrich CF. Reference values in abdominal ultrasound – Liver and liver vessels. Z Gastroenterol 2010;48:1141-52.
6. Borchert D, Schuler A, Muche R, Haenle MM, Akinli AS, Arnold F, *et al.* Comparison of panorama ultrasonography, conventional B-mode ultrasonography, and computed tomography for measuring liver size. Ultraschall Med 2010;31:31-6.
7. Silva RM, Pereira RB, Siqueira MV. Correlation between clinical evaluation of liver size versus ultrasonography evaluation according to body mass index (BMI) and biotypes. Rev Med Chil 2010;138:1495-501.
8. Borner N, Schwerk WB, Braun B. Leberin. In: Braun B, Gunther R, Schwerk WB, editors. Ultra Schall Diagnostik. Landsberg: Ecomed; 1987.
9. Gosink BB, Leymaster CE. Ultrasonic determination of hepatomegaly. J Clin Ultrasound 1981;9:37-44.
10. Kratzer W, Fritz V, Mason RA, Haenle MM, Kaechele V, Roemerstein Study Group. *et al.* Factors affecting liver size: A sonographic survey of 2080 subjects. J Ultrasound Med 2003;22:1155-61.
11. Patzak M, Porzner M, Oeztuerk S, Mason RA, Wilhelm M, Graeter T, *et al.* Assessment of liver size by ultrasonography. J Clin Ultrasound 2014;42:399-404.
12. Andersen V, Sonne J, Sletting S, Prip A. The volume of the liver in patients correlates to body weight and alcohol consumption. Alcohol Alcohol 2000;35:531-2.
13. Kwo PY, Ramchandani VA, O'Connor S, Amann D, Carr LG, Sandrasegaran K, *et al.* Gender differences in alcohol metabolism: Relationship to liver volume and effect of adjusting for body mass. Gastroenterology 1998;115:1552-7.
14. Choukèr A, Martignoni A, Dugas M, Eisenmenger W, Schauer R, Kaufmann I, *et al.* Estimation of liver size for liver transplantation: The impact of age and gender. Liver Transpl 2004;10:678-85.
15. Bahirwani R, Reddy KR. Review article: The evaluation of solitary liver masses. Aliment Pharmacol Ther 2008;28:953-65.
16. Konuş OL, Ozdemir A, Akkaya A, Erbaş G, Celik H, Işik S, *et al.* Normal liver, spleen, and kidney dimensions in neonates, infants, and children: Evaluation with sonography. AJR Am J Roentgenol 1998;171:1693-8.
17. Toukan A, Al-Adli M. Liver size in normal subject as estimated by percussion. JMJ 1985;19:169-75.
18. Niederau C, Sonnenberg A, Müller JE, Erckenbrecht JF, Scholten T, Fritsch WP, *et al.* Sonographic measurements of the normal liver, spleen, pancreas, and portal vein. Radiology 1983;149:537-40.