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Sohail Ahmed Khan
Dow University of Health Sciences, Karachi

Saira Yasmeen
Dow University of Health Sciences, Karachi,

Hatem Adil
Dow University of Health Science Karachi

Syed Omair Adil
Dow University of Health Science Karachi

Farheen Huda
Dow University of Health Sciences Karachi

See next page for additional authors

Authors
Sohail Ahmed Khan, Saira Yasmeen, Hatem Adil, Syed Omair Adil, Farheen Huda, and Shahmeer Khan

ORIGINAL ARTICLE

Sonographic Evaluation of Normal Liver, Spleen, and Renal Parameters in Adult Population: A Multicenter Study

Sohail Ahmed Khan[1], Saira Yasmeen[1], Hatem Adel[1], Syed Omair Adil[2], Farheen Huda[1] and Shahmeer Khan[3]

Abstract

Objective: To determine the normal liver, spleen, and renal parameters in adult patients with no comorbidities.

Study Design: Cross-sectional study.

Place and Duration of Study: Dow Institute of Radiology, Ojha Campus, LEJ Campus, and Al-Mustafa Hospital Karachi, from October 2016 to March 2017.

Methodology: A total of 3,136 study participants with more than 16 years of age of either gender underwent ultrasound examination. All individuals with morbid conditions like hypertension (HTN), diabetes mellitus (DM), liver cirrhosis, hydronephrosis, renal cyst, and liver mass were excluded. Ultrasound scan was performed and longitudinal and transverse sections were obtained of both kidneys (in full inspiration), spleen and liver.

Results: A significant positive correlation was observed between age and spleen size of the individuals (r=0.053, p=0.012). The correlation of BMI and liver size was also found significantly positive (r=0.237, p <0.001). The correlation of age and kidney size was found significantly negative in between age and right kidney (r=-0.074, p <0.001) and left kidney (r=-0.087, p <0.001). Similarly, the correlation of BMI and renal size was found significantly weak positive between BMI and right kidney (r=0.206, p <0.001) and BMI and left kidney (r=0.227, p <0.001).

Conclusion: BMI was found significantly positively correlated with liver size and both kidneys in study participants. Moreover, spleen was found directly and renal size inversely correlated with age of the individuals.

Key Words: *Normal liver, Spleen and renal parameters, Adult patients.*

INTRODUCTION

Liver, spleen, and renal sizes can be affected by many diseases, ranging from infective etiology to malignant disorders. The standard bedside techniques of palpation and percussion to document liver and spleen size are far from accurate to detect small increase in size.[1]

Ultrasound is a non-invasive, inexpensive, established, safe, quick and accurate method for measurement of liver, spleen, and kidneys sizes and can be performed at bedside. This provides important anatomical details of these viscera to the clinician with a low inter-observer variability.[2] However, prior knowledge of actual normal size of these viscera is required in the population being studied. False-positive labelling of a patient as having visceromegaly can lead to unnecessary medical tests, anxiety as well as healthcare expenditure.

Current literature states that 95% of adult spleens are less than 12 cm in length.[3,4] According to few studies, spleen length or volume showed a positive correlation with body height, and possibly with gender as well.[5,6] Liver is normally measured in mid clavicular line and has normal cranio-caudal length of up to 16 cm.[7] Various anthropometric measures can affect the hepatic size. However, there is only limited data available in literature for standard sonographic measurement of liver in Pakistani population.

The adult kidney is described by leading anatomy text as 3 cm deep, 6 cm wide, and 12 cm long.[8] Moreover, various studies has reported variation of renal size with age, gender, body mass index (BMI), pregnancy and co-morbid conditions.[9] Few studies have been designed to measure renal length and cortical thickness in adults, who do not have renal disease.[10]

This study was planned with the aim to determine the normal liver, spleen and renal parameters including renal length and cortical thickness in a set of local population.

METHODOLOGY

This multicentre cross-sectional study was conducted at Dow Institute of Radiology, Ojha Campus, LEJ Campus, and Al-Mustafa Hospital Karachi, through non-probability consecutive sampling from October 2016 to March 2017. Institutional approval was obtained prior to conducting of the study. Informed consent was also obtained from all participants after explaining the study protocol.

[1] *Dow Institute of Radiology, Dow University of Health Sciences, Karachi, Pakistan*
[2] *Department of Research, Dow University of Health Sciences, Karachi, Pakistan*
[3] *Department of Radiology, The Aga Khan University Hospital, Karachi, Pakistan*

Correspondence: Dr. Sohail Ahmed Khan, Department of Radiology, Dow Institute of Radiology, Dow University of Health Sciences, Karachi, Pakistan
E-mail: ahmedsohail.dr@gmail.com

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A total of 3,136 study participants of more than 16 years of age, of either gender, underwent ultrasound examination. Out of these, 924 participants were excluded due to the presence of comorbid conditions like hypertension (n=665 - 71.96%), diabetes mellitus (n=305 - 33.01%), liver cirrhosis (n=140 - 15.15%), hydronephrosis (n=112 - 12.12%), renal cyst (n=88 - 9.52%), while 65 (7.03%) participants were excluded due to the presence of liver mass.

The ultrasound examination was performed with high-resolution real-time ultrasound machines (GE Voluson S8 in Ojha Campus and LEJ and Xario 100, Toshiba in Al-Mustafa Hospital, Karachi, using 3.5-MHz convex transducer). Ultrasound scan was performed by sonologist with at least 5 years' experience.

The measurements of organ dimensions were made during deep inspiration. Liver measurements were performed in supine position. The longitudinal axis was measured after clear visualisation of liver in mid-clavicular plane with simultaneous demonstration of right kidney. The measurement of spleen length was the maximum distance at the splenic hilum on longitudinal coronal view, between the most supero-medial and the most infero-lateral points. Renal length was measured as the longest longitudinal diameter, with the patient in lateral decubitus position. All measured organs had normal position, shape and echotexture.

Data were analysed by using SPSS version 21. Descriptive statistics, mean and standard deviation, were used presenting variables like age, height, weight, BMI, spleen size, liver size, right kidney size, and left kidney size; whereas, frequencies and percentages for gender of the participants. Independent t-test and one-way ANOVA test was applied to compare the spleen size, liver size and renal parameters with age, gender and BMI. The p-value <0.05 was taken as significant. Pearson correlation test was also applied to find the relationship of spleen size, liver and renal parameters with age and BMI of the study participants.

RESULTS

A total of 2,212 participants were enrolled in the study. Mean age of the participants was 38.06 ±13.97 year (minimum 15, maximum 87 years). There were 1,139 (51.5%) males and 1,073 (48.5%) females. Overall, mean height, weight and BMI of the study participants were 161.59 ±12.20 cm, 68.08 ±16.09 Kg, 26.16 ±6.45 Kg/m^2 respectively. Majority of the participants (n=1068 - 48.3%) were overweight, followed by normal BMI (n=527 - 23.8%), obese (n=481 - 21.7%). The mean spleen size and liver size of the participants was 9.81 ±1.73 cm and 13.74 ±1.63 cm, respectively.

Table I (a): Comparison of spleen size, liver size, and kidney size with respect to BMI of the patients (n=2212).

	BMI (Total n=2212)				p-value†	Comparison group	Post hoc p-value
	Mean ±SD Underweight (1) (n=136)	Mean ±SD Normal (2) (n=527)	Mean ±SD Overweight (3) (n=1068)	Mean ±SD Obese (4) (n=481)			
Spleen size	9.38 ±0.98	9.89 ±1.75	9.77 ±1.73	9.95 ±1.83	0.004	1 vs. 2	0.013*
						1 vs. 3	0.07*
						1vs. 4	0.004*
						2 vs. 3	0.566
						2 vs. 4	0.924
						3 vs. 4	0.198
Liver size	13.14 ±1.07	13.36 ±1.25	13.70 ±1.67	14.43 ±1.81	<0.001**	1 vs. 2	0.439
						1 vs. 3	<0.001**
						1vs. 4	<0.001**
						2 vs. 3	<0.001**
						2 vs. 4	<0.001**
						3 vs. 4	<0.001**
Right kidney size	9.81 ±0.99	9.97 ±0.85	10.26 ±0.88	10.51 ±1.01	<0.001**	1 vs. 2	0.257
						1 vs. 3	<0.001**
						1 vs. 4	<0.001**
						2 vs. 3	<0.001**
						2 vs. 4	<0.001**
						3 vs. 4	<0.001**
Left kidney size	9.92 ±0.99	10.18 ±0.76	10.25 ±0.96	10.71 ±1.01	<0.001**	1 vs. 2	0.018*
						1 vs. 3	<0.001**
						1vs. 4	<0.001**
						2 vs. 3	0.568
						2 vs. 4	<0.001**
						3 vs. 4	<0.001**

SD = Standard Deviation; BMI = Body Mass Index
BMI Categories: (1) Underweight <18.5 kg/m^2, (2) Normal 18.5-22.5 kg/m^2, (3) Overweight 22.6-30 kg/m^2, (4) Obese >30 kg/m^2
*†One-way ANOVA test applied; **p-value <0.0001; *p-value <0.05*

Table I (b): Comparison of spleen size, liver size, and kidney size with respect to BMI of the patients (n=2212).

BMI (Male, n=1139)						
Mean ±SD Underweight (1) (n=60)	Mean ±SD Normal (2) (n=276)	Mean ±SD Overweight (3) (n=572)	Mean ±SD Obese (4) (n=231)	p-value†	Comparison group	Post hoc p-value
9.50 ±1.16	10.13 ±1.77	10.17 ±1.76	10.35 ±1.65	0.008*	1 vs. 2	0.048*
					1 vs. 3	0.021*
					1vs. 4	0.004*
					2 vs. 3	0.991
					2 vs. 4	0.482
					3 vs. 4	0.527
13.43 ±0.72	13.28 ±1.16	13.64 ±1.78	13.85 ±1.72	0.001**	1 vs. 2	0.914
					1 vs. 3	0.773
					1vs. 4	0.269
					2 vs. 3	0.013*
					2 vs. 4	<0.001**
					3 vs. 4	0.325
9.77 ±0.86	10.12 ±0.69	10.31 ±0.84	10.64 ±1.02	<0.001**	1 vs. 2	0.023*
					1 vs. 3	<0.001**
					1vs. 4	<0.001**
					2 vs. 3	0.01*
					2 vs. 4	<0.001**
					3 vs. 4	<0.001**
9.91 ±1.11	10.14 ±0.77	10.36 ±1.01	10.87 ±0.92	<0.001**	1 vs. 2	0.343
					1 vs. 3	0.003*
					1vs. 4	<0.001**
					2 vs. 3	0.007
					2 vs. 4	<0.001**
					3 vs. 4	<0.001**
BMI (Female, n=1073)						
Mean ±SD Underweight (1) (n=76)	Mean ±SD Normal (2) (n=251)	Mean ±SD Overweight (3) (n=496)	Mean ±SD Obese (4) (n=250)	p-value†	Comparison group	Post hoc p-value
9.29 ±0.81	9.61 ±1.69	9.31 ±1.58	9.59 ±1.91	0.032	1 vs. 2	0.441
					1 vs. 3	1
					1vs. 4	0.522
					2 vs. 3	0.071
					2 vs. 4	0.998
					3 vs. 4	0.12
12.90 ±1.23	13.45 ±1.36	13.77 ±1.55	14.96 ±1.73	<0.001	1 vs. 2	0.03*
					1 vs. 3	<0.001**
					1vs. 4	<0.001**
					2 vs. 3	0.033
					2 vs. 4	<0.001**
					3 vs. 4	<0.001**
9.85 ±1.09	9.82 ±0.97	10.20 ±0.94	10.40 ±0.98	<0.001	1 vs. 2	0.997
					1 vs. 3	0.018*
					1vs. 4	<0.001**
					2 vs. 3	<0.001**
					2 vs. 4	<0.001**
					3 vs. 4	<0.001**
9.93 ±0.89	10.23 ±0.77	10.12 ±0.89	10.56 ±1.04	<0.001	1 vs. 2	0.046*
					1 vs. 3	0.313
					1vs. 4	<0.001**
					2 vs. 3	0.345
					2 vs. 4	<0.001**
					3 vs. 4	<0.001**

SD = Standard Deviation; BMI = Body Mass Index
BMI Categories: (1) Underweight <18.5 kg/m2, (2) Normal 18.5-22.5 kg/m2, (3) Overweight 22.6-30 kg/m2, (4) Obese >30 kg/m2
*†One-way ANOVA test applied, **p-value <0.0001, *p-value <0.05*

Table II: Correlation of age and BMI with spleen, liver, and renal sizes with respect to gender (n=2212).

	Spleen size		Liver size		Right side of kidney		Left side of kidney	
	r	p-value	r	p-value	r	p-value	r	p-value
Age (years)								
Total (n=2212)	0.053	0.012*	0.041*	0.056	-0.074**	<0.001	-0.087**	<0.001
Male (n=1139)	0.101**	<0.001	-0.034	0.247	-0.088**	0.003	-0.044	0.135
Female (n=1073)	-0.013	0.659	0.133**	<0.001	-0.064*	0.036	-0.146**	<0.001
BMI (kg/m^2)								
Total (n=2212)	0.015	0.476	0.237**	<0.001	0.206**	<0.001	0.227**	<0.001
Male (n=1139)	0.135**	<0.001	0.118**	<0.001	0.118**	<0.001	0.198**	<0.001
Female (n=1073)	0.002	0.956	0.332**	<0.001	0.199**	<0.001	0.183**	<0.001

*Pearson correlation test applied; **Correlation is significant at 0.001 level; * Correlation is significant at 0.05 level; r = Pearson correlation value; n = number.*

Significant difference of liver size (p <0.001) and spleen size (p=0.012) was observed with respect to age of the individuals. Mean spleen size was significantly higher in males than that of females (10.16 ±1.72 cm vs. 9.44 ±1.65 cm, p <0.001). However, liver size was significantly higher in females than that of males (13.91 ±1.64cm vs. 13.59 ±1.61 cm, p <0.001). A significant difference of BMI categories was also observed with spleen size (p 0.004) and liver size of the individuals (p <0.001). Post Hoc test revealed significant difference of spleen size between underweight and normal BMI individuals (p=0.013), underweight and overweight (p=0.07) and underweight and obese subjects (p=0.004) as shown in Table I.

A significant positive correlation was observed between age and spleen size of the individuals (r=0.053, p=0.012). However, insignificant positive correlation was observed in between age and liver size of the individuals (r=0.041, p= 0.056). Similarly, the correlation of BMI and liver size was also found significantly positive (r=0.237, p <0.001). However, insignificant positive correlation was observed between BMI and spleen size of the individuals (r=0.015, p=0.476) as given in Table II.

The mean size of right kidney was 10.24 ±1.06 cm with the cortical thickness of 1.19 ±0.12 cm, while mean size of left kidney was 10.31 ±0.97 cm with the cortical thickness of 1.26 ±0.14 cm.

Significant difference of right renal (p <0.001) and left renal size (p <0.001) was observed with respect to age of the individuals. In males, the mean size of right and left kidney was significantly higher than that of females (10.30 ±0.87 cm vs. 10.18 ±1.22 cm, p=0.010 and 10.38 ±0.98 cm vs. 10.23 ±0.92 cm, p <0.001, respectively). A significant difference of BMI categories was also observed with both kidneys (p <0.001). Post Hoc test has revealed significant difference of right and left renal sizes between underweight and overweight (p <0.001), underweight and obese (p <0.001), normal BMI and obese (p <0.001), and overweight and obese (p <0.001) as shown in Table I.

The correlation of age and kidney size was found significantly negative between age and right kidney (r=-0.074, p <0.001) and left kidney (r=-0.087, p <0.001). Similarly, the correlation of BMI and renal size was found significantly weak positive in between BMI and right kidney (r=0.206, p <0.001) and BMI and left kidney (r=0.227, p <0.001). This is given in Table II.

DISCUSSION

The findings of renal length and cortical thickness of the current study among asymptomatic individuals were comparable to those reported literature. However, renal length in asymptomatic population was relatively lower than those reported from other regions.[11-13] It can be hypothesised that racial and genetic influence can exist among the study subjects of different countries based upon body types, size and habitus.

In the current study, age had a significant negative correlation with the renal size. Maximum renal length was observed in age group of 31 to 40 years followed by a rapid decline in their size from 60 year onwards. These results are comparable with another study.[14] This may be due to age related decline in renal function in patients of more than 60 year age.[2] The average renal size was comparatively lower in population aged 60 years and above.

Lengths of both kidneys and BMI had a significant positive correlation in the current study. These results are comparable with other studies.[2,14] Obese individuals showed the greater and underweight subjects the smallest renal length. Possible reason for this could be the fact that the kidneys develop at the same rate as that of whole body.

The mean splenic length of the individuals included in the current study was comparable to that reported in the regional literature from Rajasthan population.[15] However, this is in contrast to a study where greater values of spleen size have been reported.[16] Again, a possibility of genetic, nutritional, and socioeconomic factors cannot be denied. Current study demonstrated that splenic length was significantly higher in males and was comparable to other studies.[6,15,16] A speculation behind this observation could be due to shorter height of females. Current study showed a significant positive correlation of spleen length with respect to age of 60 years and insignificant correlation with BMI. The study

also showed that spleen length in subjects aged between 20 to 60 years remained relatively homogenous. Our findings are in agreement with findings described in Indian population.[17] These results are in contrast with many other studies that showed no significant correlation between splenic size and volume with age.[18,19]

The mean liver size was found comparable to Indian population.[20] Liver size in our population was higher as compared with Jordanians, and Saudis and lower as compared to Germans.[21-24] This implies ethnic, social, and cultural differences in attainment of final liver size. Liver size was surprisingly greater in females than males. These results are in contrast with most of the previous studies.[20-22,24] In our population, obesity was more common in women having non-alcoholic fatty liver disease in Pakistan. The surprising higher liver size in females as compared to males could be due to the fact that fatty infiltration of liver may be responsible for increase in liver size among females.[25] According to current study, BMI showed significant positive correlation with liver size. This is comparable to other studies.[23,24] Height and weight are also independent predictors of liver size.[21,22] Liver is the site of fatty infiltration and overweight or obese people may have increase in amount of fatty infiltration in liver leading to large liver size.

There are few limitations of the study. It focused on linear parameters such as length and thickness. Volumetric data of organs is not obtained. Despite the limitation, current study is an effort to report normal renal, spleen, and liver sizes in a large cohort from multiple centres. It is recommended that further studies focusing on volumetric parameters should be carried out in healthy individuals to get further insight to the normal anatomy. Moreover, three dimensional studies utilising computed tomography and magnetic resonance imaging, can be carried out for documenting anatomy and its variants in the Pakistani population.

CONCLUSION

The index study provided normal sonographic renal, hepatic, and splenic dimensions in Pakistani population and documented their correlation with age, gender, and BMI. Significant positive correlation of renal size was established with left side, male gender, and increasing BMI; while decline in renal size was noticed after the age 60 years. Strong positive correlation of splenic size with age and hepatic size with BMI was observed. Moreover, splenic size was greater in males than females and vice versa for liver.

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