Original Article

Normative Data of Liver Volume in Indian Adult Population

Pawan Agarwal[1], Bharath S[2], Ayush Dixit[3], Dhananjaya Sharma[4], Jag Mohan Singh Dhakar[5]

Abstract

Background : Aim of this study is to establish normative data for the liver volume in healthy Indian adult population.

Materials and Methods : 517 healthy adults age ranging from 20-75 years, 267 males and 250 females underwent ultrasonographic assessment of liver volume. Liver volume was correlated with age, gender, Body Surface Area (BSA) and Body Mass Index (BMI) of the participants.

Results : The overall mean liver volume was 913 cc. The liver volume increases with increasing age up to 50 years and decreases after that. Mean liver volume in male was slightly more than in female (936.84 cc *versus* 882.70cc). Mean Liver volume increases with increasing BMI and was found to be statistically significant below 40 years of age. BSA has positive correlation with liver volume up to 50 years of age.

Conclusion : Normative data on the liver volume in Indian adult population correlates with age, gender, BMI and BSA and all the factors correlate significantly except BSA.

Key words : Adult, Liver, Measurements, Ultrasonography, Normal Volume, Indian.

Liver size varies amongst normal individuals according to age, gender, Body Mass Index (BMI), ethnicity and various conditions affecting the liver. Estimation of liver size has critical implications for assessment of liver disorders, major hepatic resection and also in liver transplant surgery especially to avoid donor-recipient graft mismatch[1-4]. Size of liver can be assessed clinically by estimating liver span by percussion; but may not be accurate[5]. Liver size can be determined using the ultrasound measurements of the right lobe of liver. However, it does not provide dimensional information of whole liver therefore calculation of liver volume gives a more accurate measurement of liver size[6]. As the available literature is scarce, we aimed to establish standards of liver volume by ultrasonography in healthy Indian adults.

Editor's Comment :

- The overall mean liver volume was 913cc and increases with increasing age and BMI. Mean liver volume in male was slightly more than in female.
- Normative data on the liver volume in Indian adult population correlate with age, weight, height, BMI and BSA and all the factors were correlated significantly except BSA.

Materials and Methods

Institutional ethical committee clearance and written informed consent from all participants was taken before initiating the study.

We enrolled 517 asymptomatic adults age ranging from 20-75 years, visiting the outpatient department accompanying their relatives for treatment, between January, 2023 - March, 2023. Those having any condition which could affect the size of the liver such as liver disease, malaria, hemolytic anemia, enteric fever, congestive heart failure were excluded. Written /informed, consent was obtained from all participants. Baseline data including the age, sex, height and weight were recorded. Ultrasonography was used to assess the volume of liver by a single radiologist. Alpinion-eCUBE i7 USG machine (BPL Medical Technologies equipment Manufacturing company, Bangalore- India) was used with C16CT Curvilinear probe and frequency range 1-6 MHz. Liver volume was calculated using the formula[6] Liver volume (cc) = 343.71+(0.84x ABC) where A=Left lobe AP, B (right lobe DT) and C (right lobe AP) (Figs 1-3) Statistical analysis was done using SPSS version 22.

Results

517 healthy individual age ranging from 20-75 years,

Netaji Subhash Chandra Bose Medical College, Jabalpur, Madhya Pradesh 48200
[1]MS, MCh, (Plastic Surgery) FRCS (Glasgow), DNB, MNAMS, PhD, FICS, Professor and Head, Department of Plastic Surgery and Corresponding Author
[2]MS, Senior Resident, Department of General Surgery
[3]MD, Senior Resident, Department of Radiology
[4]MS, PhD, FRCS, Professor and Head, Department of General Surgery
[5]MSc, Tutor, Department of Community Medicine
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Fig 1 — USG measurement of left lobe AP

Fig 2 — USG measurement of right lobe DT

Fig 3 — USG measurement of right lobe AP

267 males and 250 females were included in this study. Their demographics are shown in Table 1. The overall mean liver volume was 913 cc (range- 510-1607 cc) and mean liver span was 12.9 cm (range-9.3- 15.4 cm). Mean weight of individuals was 58.1 kg (range-32-89 kg), mean height of individuals was 1.61 m (range-1.24-1.93 m) and mean BMI of individuals was 22.4 (range-13.7-36.9).

Mean Liver volume increased till the age of 50 years and then decreased (Table 2). Mean liver volume in male was 936.84 cc and in female 882.70cc. Mean Liver volume was overall less in females but statistical significance was found only at 20-30 years of age (p=0.003)(Table 3).

Mean liver volume in normal weight, overweight and obese subjects was 905.87cc, 944.80 cc and 1081.72 cc respectively. Mean Liver volume increases with BMI and is statistically significant below 40 years of age (p-0.005)(Table 4). Body Surface Area (BSA) has positive correlation with liver volume up to 50 years meaning with increasing BSA liver volume increases and after that it has no correlation. Liver volume correlated significantly (Pearson Correlation) with age, weight, height, gender, and BMI and not with BSA (Tables 5,6).

Table 2 — *Mean Liver volume according to the Age*

Age (in years)	Mean Liver volume (cc)	p value
20-30	885.12	0.009
31-40	944.33	
41-50	943.84	
51-60	907.94	
>60	897.76	

Table 3 — *Mean Liver volume according to the Gender*

Age (in years)	Mean Liver volume (cc)		
	Male	Female	p value
20-30	922.43	859.96	0.003
31-40	965.76	921.09	0.195
41-50	949.75	935.14	0.653
51-60	932.25	853.90	0.123
>60	914.04	843.41	0.433

Table 4 — *Mean Liver volume according to BMI*

Age (in years)	Mean Liver volume (cc)				
	Under weight	Normal	Overweight	Obese	p value
20-30	863.95	876.72	918.94	1102.67	0.005
31-40	919.62	916.18	996.49	1113.39	0.031
41-50	900.08	946.06	946.56	943.84	0.862
51-60	912.82	892.33	917.22	1166.98	0.209
>60	895.25	898.08	NA	NA	0.981

Discussion

The normal size of liver according to age, gender, BSA and BMI has not been specified in the standard textbooks. Such normative data on liver volume can be useful for clinicians to diagnose liver disease, track disease progress and response to treatment[7]. In liver transplantation liver volume is an independent determinant of the prognosis of liver graft as overestimation of the donor's liver volume may result in excessive hepatic resection leading to liver failure while underestimation of the recipient's liver volume may result in small-for-size graft syndrome[8,9]. In major hepatic resection the safety and efficacy of the procedures depends on the accurate calculation of

Table 1 — Showing Frequency distribution of population

	Age in years				Gender		BMI			
20-30	31-40	41-50	51-60	>60	Male	Female	Under Weight	Normal	Over weight	Obese
216	123	94	58	26	267	250	53	368	80	16
41.8%	23.8%	18.2%	11.2%	5%	51.6	48.4	10.3%	71.2%	15.5%	3.1%

Table 5 — *Correlations between Liver Volume and BSA*

Parameters	Age Group				
Correlation between BSA and Mean Liver volume (r)	20-30	31-40	41-50	51-60	>60
	r = 0.07	r = 0.066	r = 0.129	r = -0.076	r = -0.30

Table 6 — *Correlations between Liver Volume and Demographic variables*

Liver Volume	Age (in years)	Weight (in kg)	Height (in M)	BMI	BSA
Pearson Correlation	0.094*	0.345*	0.209*	0.227*	.048

*Correlation is significant at the 0.05 level.

existing and remnant liver volume[10]. The normative chart also has implications for clinical practice as using the available reference charts, frequency of hepatomegaly in the absence of other findings of liver disease may lead to unnecessary consultations, laboratory tests, with associated unnecessary cost and uncertainty for the affected families[1,11].

There is no perfect way to measure liver volume as this cannot be done with the organ in-situ. Liver diameters can be measured by CT/MRI scans[12], however; these imaging modalities are expensive, less mobile/accessible; moreover, radiation exposure associated with CT and claustrophobia associated with MRI are additional disadvantages[13,14]. It should also be noted that the volume measurements determined by the liver segmentation and analysis software has not been compared to actual liver volumes with the error of the CT volumetry is ~ 5%-10%[15,16]. Ultrasonography is a non-invasive, inexpensive, safe, quick, radiation-free and accurate method for measurement of liver size[17]. Only a limited number of studies of normative liver size have been published and there are few Indian studies which have been done in paediatric population[1,3].

There is evidence to prove that there is a direct correlation between the body indices and the liver volume as it reflects the individual's hepatic metabolic demands[18]. Body habitus such as BSA and BMI are the most important factors associated with the liver dimensions though age and gender also to a lesser degree influence the size of the liver[19-21].

Exact correlation of liver volume with age is not known; in children liver volume increases with age[22]. In adults the liver volume would decrease with aging. However, decrease in liver volume may not produce a decrease in liver function[23]. Some studies did not find a significant difference between the two genders in liver dimensions[11,20]. but other studies demonstrated significantly larger liver in men[24]. Our study showed that liver volume is less in females may be due to their shorter stature, less weight and less BMI. The liver volume became smaller in both male and females along with aging. Females have decreased in liver volume at least a decade later as compared to male due to hormonal differences between the genders. Oestrogen was found to be a hepatotropic factor, which could facilitate liver regeneration[25]. Some studies show liver volume significantly correlated with BSA but weak correlation with BMI indicates that liver volume increases proportionally with BSA not obesity status per se[26]. However, in our study liver volume significantly correlated with BMI and not with BSA. Liver size also differs between ethnic groups possibly due to different BMI and body size[11,20,21].

Our study provides a standard set of normal range of liver volume according to age, gender, BMI and BSA of adults determined by ultrasonography. We recommend measuring the liver volume and comparing it with the reference charts in cases of liver disease. Limitation of study include all measurements were obtained by a single radiologist hence inter-observer variation could not be accounted for. On the other hand by having all measurements performed by one radiologist, we have achieved a high level of standardization.

Conclusion

Normative data on the liver volume in Indian adult population correlate with age, weight, height, BMI and BSA and all the factors were correlated significantly except BSA.

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