IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 1 Ser. 13 (January. 2019), PP 64-69
www.iosrjournals.org

Standard Formulae in Predicting Norms of Sudanese Liver Volume: A CT based study

Amel Ahmed Ali Mohammed[1], Caroline Edward Ayad[2]
[1](King Khalid University, College Of Applied Medical Science –Radiology Department .Saudi-Arabia)
[2](Sudan Univesity Of Science And Technology-College Of Medical Radiological Science-Khartoum Sudan)
Corresponding Author: Amel Ahmed Ali Mohammed

Abstract: *This Cross-sectional, hospital-based study was obtained to establish normative data for the Computerized Tomography (CT) measurement of liver volume and dimensions in healthy Sudanese Subjects. The study took place at Alkuwaitti Specialized Hospital. The participants were 197 healthy Sudanese adults; their ages were between 18year to 82 years old. CT evaluation for the liver volume and dimensions was obtained. The liver volume was correlated with the age, gender, weight, BSA, total body water contents, Hounsfield (HU) and other liver dimensions of the participants .The current study found that the minimum liver volume was 1010 cm^3 , maximum volume was 2153cm3 and mean value of 1444.48±218.11cm3 for Sudanese populations with mean age of 44.73±16.75.This was considered greater than what was mentioned in other populations .The liver volume was significantly correlated with age at p=0.039 Right Lobe craniocaudal(CC)at p=0.000, Right Lobe antroposterior (AP)p=0.000, Right Lobe lateral (LAT)p=0.045), Left Lobe length p= 0.002 ,with no difference between the two genders except for the total body water contents at p=0.002.*
Two new formulae available to calculate standard liver volume for Sudanese were established. The formula are based on body surface area ,total body water , patients weight, age and liver CT number measured in HU as well as Right Lobe (CC), Right Lobe (AP),Right Lobe (LAT) and Left Lobe length. Liver Volume measured from Eastern and Western population most farley estimates liver volumes for Sudanese population, with a slight underestimation. Our formulae are acknowledged for calculating liver volume using CT scans
Keywords – *Liver volume, age, CT scan ,BSA*

Date of Submission: 11-01-2019 Date of acceptance: 27-01-2019

I. Introduction

Estimation of liver measurements can be used as an index to monitor various aspects of liver disease and response to treatment. Liver size vary widely according to age. Many diseases can also affect their measurements, ranging from infection to malignant disorders [1, 2]. Palpation and percussion are the standard bedside techniques to document liver size, but are far from accurate to detect small increase in measurements [3,4] .Living donor and split-liver transplantation techniques necessitate the calculation of a standard liver volume (LV) as a reference point for the minimal volume required for the receiver. It is necessary to have a calculable LV. [5] Urata et al[6] calculated the LV from body surface area (BSA) in the Japanese population. They established a formula by means of a regression analysis of liver volume (LV) measurements using the computed tomography (CT) scans of both children and adult patients without liver abnormalities. The Japanese formula has been widely used by American, as well as European, groups working in liver transplantation. Also a formula developed by Urata et al [6]was also been used regarding that issue ,Gaucasian population have their equation with new formula for the calculation of LV was established[7] . Many formulae derived from international centers were also been used :Hashimoto et al. [8]Japan ,Vauthey et al.[9] for US ,Fu-Gui et al. [10]for Chinese, Chandramohan et al. [11]for Indian, Chan et al.[12] for Hong Kong ,A. Poovathumkadavil et al.[13]for Saudi Arabia ,and Lui SA et al[14] for South East Asian population.

Imaging-based volumetry has been increasingly utilized in current clinical practice to obtain accurate measurements of the liver volume. This is particularly useful prior to major hepatic resection and living donor liver transplantation where the size of the remnant liver and liver graft, respectively, affects procedural success and postoperative death .All of the above previous studies showed that such formulae have different accuracy based on the population studied. To date, and to the best of our knowledge no such study has been carried out in Sudanese population.

II. Materials And Methods

This study aimed to measure the liver volume in normal Sudanese population in order to establish the normal liver values in contrast with international index. Study population included all patients who underwent Triphasic CT abdomen at Alkuwaitti Specialized Hospital. Patient with normal abdominal scan were the target of this study. This study was excluding many patients with the underlying condition; Patient with focal liver lesions, intra-hepatic duct dilatation, pancreatic mass, ampullary mass, known tumor and HCC, metastatic liver disease, patients with previous surgical liver intervention, patients with hepatobiliary diseases leading to hepatomegally or splenomegaly or any other diseases leading to affect the liver volume were excluded from these measurement. Measurement were done using GE optima-16 slice machine and work station (PACS), where the volume was measured. The sample included 87(44.2) females, and 110(55.8) males, their ages were 18-26(27,13.7%),27-34(42,21.3%),35-42(30,15.2%),43-50(28,14.2%),51-58(14,7.1%),59-66(31,15.7),67-74(20,10.2%)75-82(5,2.05%)

Patient scan:

First the patients were prepared for triphasic or routine CT abdomen scan by fasting of 4-6 hours, oral negative contrast with omnipaque IV contrast used for study of abdominal organs in case of liver scan the true arterial angiographic phase aimed to assess the normal vasculature of the liver and abdomen the after 50-60 second the next scan porto-venous phase done and this phase all abdominal organs are well perfused by contrast and specially the liver parenchyma, then delayed phase also done to assess the KUB organs and the liver lesions that need for delayed time in which done in mean time between 6-10 min after contrast injection. In Routine CT abdomen only two scan were done which include axial without contrast and Porto venous phase. Then the images were transferred to the PACS for proper image diagnosis where the normal images were recognized and classified to routine and triphasic CT abdomen then the measurement were done in reformatted images the volume is measured in axial slice, measurement is done in Porto venous phase in which actual liver perfusion is optimally taken at slice thickness equal to 0.625mm and interval equal to 0.625mm then the volume is then measured every 2mm interval and the collective volume is measured using standard GE optima 16 slice machine software specified for volume measures. Then the rest of measurement were taken from reformatted images as follow: axial (AP for right lobe measures including the quadrate lobe form the upper most to lower most border at the level of mid clavicular line, then the lateral measurement from the tip of the quadate lobe to lateral most border and then the quadate lobe alone measured till the oblique junction between the IVC and portal vein) the craniocaudal measures is done at coronal section for the from the dome of the liver superiorly to the lower most corner of the liver, the length of the left lobe also measured at sagittal section according to the most length of the lobe then the width of the left lobe measured at axial section at stander stomach volume. These measurement is then correlated with the patients age, gender, weight and height , then the total body water and BSA (body surface area was also measured to estimate the liver volume accordingly).

III. results

Table (1) demonstrate the liver volume and its measurements

Variables	Min	Max	Mean	Std. V
Liver volume/cm^3	1010	2153	1444.48	218.11
CT number of liver(Hounsfield)	83.0	166.0	110.82	12.41
Right lobe craniocaudal/cm	12.60	21.80	17.03	1.69
Right lobe (Antero-Posterior)/cm	12.50	19.80	15.89	1.35
Right lobe (Lateral)/cm	9.80	16.60	13.09	0.98
Left lobe width/cm	4.70	13.00	7.34	1.21
Left lobe length/cm	0.40	14.10	10.78	1.82
Quadate lobe/cm	3.02	5.60	4.23	0.52

Table (2) showed the statistical measures of demographic data for 197 normal patients

Variables	Min	Max	Mean	Std. V
Age/years	18.0	82.0	44.73	16.75
Weight/Kg	46.0	90.0	65.76	9.19
Height/cm	130.0	188.0	167.15	9.11
BSA (m^2)	1.41	2.13	1.74	0.13
Total body water	26.60	46.80	35.7	4.5

Table (3) Independent sample t-test showed the correlation between the liver measurement and patient gender demonstrating the mean and std. deviation at (p<0.05 and CL=95)

Variables	Gender	N	Mean	Std. Deviation
Liver volume	Female	87	1473.42	231.66
	Male	110	1421.60	204.94
Right lobe craniocaudal/cm	Female	87	17.40	1.75
	Male	110	16.74	1.59

Right lobe (Antero-Posterior)/cm	Female	87	15.82	1.37
	Male	110	15.94	1.35
Right lobe (Lateral)/cm	Female	87	12.64	0.96
	Male	110	13.45	0.85
Left Lobe width	Female	86	7.12	1.32
	Male	110	7.50	1.09
Left Lobe length	Female	87	11.06	1.66
	Male	110	10.56	1.92
Quadate lobe	Female	87	4.08	0.54
	Male	110	4.36	0.48
Total body water	Female	87	32.34	2.73
	Male	110	38.34	3.77

Table (4) showed the significant difference value for independent t-test for where the null hypothesis stated that there is no difference between patient gender and liver measurement.

	Independent Samples Test				
	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	Sig. (2-tailed)	Mean Difference
Liver volume	1.57	0.211	1.66	0.098	51.8
Age	2.32	0.129	2.64	0.009	6.3
Weight	0.31	0.577	2.71	0.007	3.5
Height	1.78	0.183	-3.65	0.000	-4.64
BSA (m^2)	0.11	0.745	0.953	0.342	0.018
HU liver	0.33	0.567	0.617	0.538	1.1
Right Lobe (CC)	0.21	0.649	2.765	0.006	0.66
Right Lobe (AP)	0.27	0.601	-0.613	0.541	-0.12
Right Lobe (LAT)	1.13	0.288	-6.237	0.000	-0.81
Left Lobe width	0.54	0.462	-2.211	0.028	-0.38
Left Lobe length	0.26	0.610	1.925	0.056	0.50
Quadate lobe	2.02	0.157	-3.830	0.000	-0.28
Total body water	9.65	0.002	-12.45	0.000	-6.0

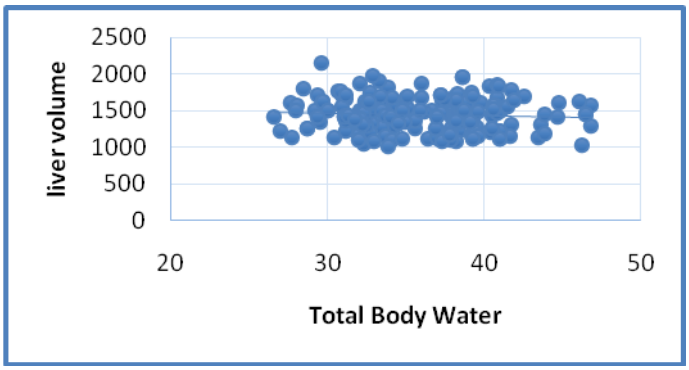


Figure (1) scatter plot showed the linear correlation between the liver volume and total body water ($y = -3.344x + 1563.9$, $R^2 = 0.0047$)

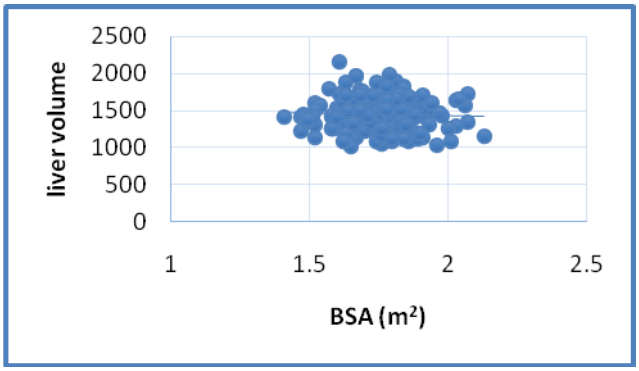


Figure (2) scatter plot showed the linear correlation between the liver volume and BSA ($y = -72.534x + 1571.1$, $R^2 = 0.002$)

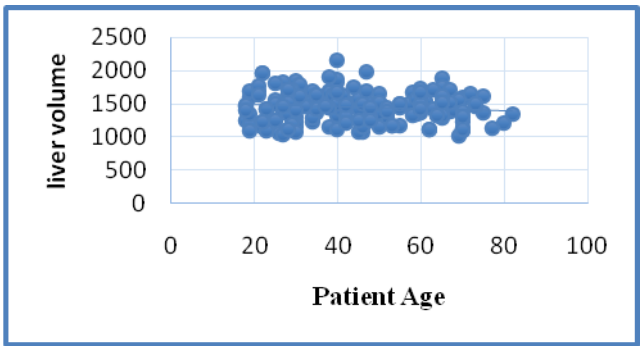
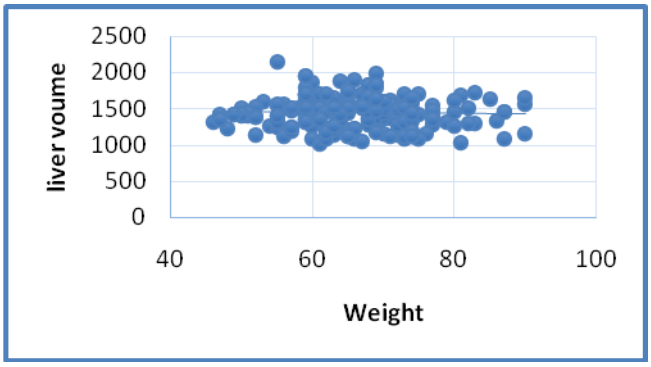


Figure (3) scatter plot showed the linear correlation between the liver volume and patient age (y = -1.4425x + 1509, R² = 0.0123)



Figure(4) scatter plot showed the linear correlation between the liver volume and patient weight **(y = -0.8586x + 1500.9, R² = 0.0013)**

Table (5) *Showed the coefficients of variables (BSA, WEIGHT, TOTAL BODY WATER, AGE, HU LIVER) and liver volume*

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1569.98	304.32		5.159	0.000
$BSAm^2$	59.12	328.31	0.036	0.180	0.857
Weight	-0.04	4.30	-0.002	-0.009	0.993
Total Body Water	-7.05	4.86	-0.145	-1.452	0.148
Age	-17.14	8.25	-0.162	-2.077	0.039
HU Liver	0.82	1.26	0.047	0.648	0.518

Dependent Variable: liver volume

Liver volume= (BSA (m^2)*59.12)+(weight*-0.04)+(total body water*-7.05)+(age*-17.14)+(HU*0.82)+1569.98

Table (6) Showed the coefficients of variables ((Right Lobe (CC), Right Lobe (AP), Right Lobe (LAT), Left Lobe width, Left Lobe length, Quadate lobe) and liver volume

Coefficients					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-706.054	250.170		-2.822	.005
Right Lobe (CC)	46.997	7.781	.369	6.040	.000
Right Lobe (AP)	48.936	10.192	.312	4.801	.000
Right Lobe (LAT)	30.268	15.009	.141	2.017	.045
Left Lobe width	1.060	11.996	.006	.088	.930
Left Lobe length	21.966	7.091	.189	3.098	.002
Quadate lobe	-16.740	26.501	-.042	-.632	.528

Dependent Variable: liver volume

Liver volume= (RTLCC*46.99)+(RTLAP*48.94)+(RTLLAT*30.27)+(LTLW*1.06)+(LTLL*21.97)+(Quadate lobe*-16.74)-706.054

IV. Discussion

Computed Tomography Imaging (CT) was used to calculate standard liver volume (LV).For this purpose, a triphasic CT scan was performed for each Sudanese patient .liver volume, dimensions and patients demographics were presented in tables (1and2) Independent sample t-test showed the correlation between the liver measurement and patient gender demonstrating the mean and standard deviation at ($p<0.05$ and CL=95) table (3)

The difference between the two genders were also been evaluated regarding the liver volume and dimensions , no significant difference detected between the two genders except for the total body water contents , it was significantly differs at p =0.002 table (4).In 1995, Urata et al. [6] proposed a formula to estimate liver volume based on body surface area using computed tomography imaging for Japanese .In the subsequent years, many centers have derived their formulas based on the population studied using different body indices including body weight, body surface area .The current study showed through scatter plot diagrams, the linear correlation between the liver volume and total body water ($y = -3.344x + 1563.9$, $R^2 = 0.0047$), liver volume and BSA ($y = -72.534x + 1571.1$, $R^2 = 0.002$) liver volume and patient age ($y = -1.4425x + 1509$, $R^2 = 0.0123$) as well as the liver volume and patient weight ($y = -0.8586x + 1500.9$, $R^2 = 0.0013$)(figures1,2,3).In the current study we found that minimum liver volume was 1010 cm^3 and maximum volume was 2153cm3 and mean value of 1444.48±218.11cm3 for group of Sudanese populations age ranged from 18-82 with mean age was 44.73±16.75.This was considered greater than what was mentioned in other populations which was likely due to the different body habitus.Many studies identified formula at predicting liver volume.the formula by Fu Gui et al. and A.Poovathumkadavil et al are closest in estimation of standard liver volume in South East Asian adults [10,13]. Of note, their formula estimate the liver volume using body weight, while the other formulas (Urata, Hashimoto, Vauthey and Chandramohan)[6,8,9,11] estimated the liver volume using body surface area. Our study used many valuable to estimate the liver formula to be considered as reference values for Sudanese.

Two formula have been established (tables 5,6)for measuring the liver volume considering BSA, weight, total body water age HU as well as liver dimensions :

Liver volume= (BSA (m^2)*59.12)+(weight*-0.04)+(total body water*-7.05)+(age*-17.14)+(HU*0.82)+1569.98

Liver volume= (RTLCC*46.99)+(RTLAP*48.94)+(RTLLAT*30.27)+(LTLW*1.06)+(LTLL*21.97)+(Quadate lobe*-16.74)-706.054

This study showed that body weight (BW), BSA, ,total body water , age and Liver HU are more important factor in predicting liver volume in Sudanese population with significantly related to age at p=0.039 as well as the Right Lobe (CC)p=.000, Right Lobe (AP)p=0 .000, Right Lobe (LAT) p=0.045 and Left Lobe length at p=0.002.On the other hand, four reported studies showed that BW is more significant than BSA [9,10,12,15] and the Body weight is preferred as a primary index, and is obtained by precise weighing measurement as opposed to BSA.

V. Conclusion

In conclusion, among the two new formulae available to calculate standard liver volume for Sudanese, the formula are based on body surface area, total body water , patients weight, age and liver CT number measured in HU as well as Right Lobe (CC), Right Lobe (AP),Right Lobe (LAT) and Left Lobe length. Liver Volume measured from Eastern and Western population most farley estimates liver volumes for Sudanese population, with a slight underestimation. Our formulae are acknowledged for calculating liver volume using CT scans

Acknowledgements

We sincerely thank the participants without whom the study would not have been feasible. The Sudan University of Science and Technology, College of Medical Radiological Science and Radiology Department in Alkuwaitti Specialized Hospital are thankfully acknowledged

References

[1]. Gao L, Heath DG, Kuszyk BS, et al. Automatic liver segmentation technique for threedimensional visualization of CT data. Radiology 1996;201:359–64.
[2]. Strunk H, Stuckmann G, Textor J, et al. Limitations and pitfalls of couinaud's segmentation of the liver in transaxial imaging. Eur Radiol 2003;13:2472–82.
[3]. Zhang B, Lewis SM. A study of the reliability of clinical palpation of the spleen. Clin Lab Haematol1989; 11: 7-10.
[4]. 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: 171-174.

[5]. Kawasaki S, Makuuchi M, Matsunami H, Hashikura Y, Ikegami T, Chisuwa H, et al. Preoperative measurement of segmental liver volume of donors for living related liver transplantation. Hepatology 1993;18:115-120.
[6]. Urata K, Kawasaki S, Matsunami H, Hashikura Y, Ikegami T, Ishizone S, et al. Calculation of child and adult standard liver volume for liver transplantation. Hepatology 1995;21:1317-1321.
[7]. *Axel Heinemann, Friedel Wischhusen,Klaus Pu¨ schel and Xavier Rogiers* **Standard Liver Volume in the Caucasian Population** *Liver Transplantation and Surgery, Vol 5, No 5 (September), 1999: pp 366-368*
[8]. Hashimoto T, Sugawara Y, Tamura S, Hasegawa K, Kishi Y,et al. (2006) Estimation of standard liver volume in Japanese living liver donors. J Gastroentero lHepatol 21: 1710-1713.
[9]. Vauthey JN, Abdalla EK, Doherty DA, Gertsch P, Fenstermacher MJ, et al. (2002) Body surface area and body weight predict total liver volume in Western adults. Liver Transpl 8: 233-240.
[10]. Fu-Gui L, Lu-Nan Y, Bo L, Yong Z, Tian-Fu W ,et al. (2009) Estimation of standard liver volume in Chinese adult living donors. Transplant Proc 41: 4052- 4056.
[11]. Chandramohan A, Eapen A, Govil S, Govil S, Jeyaseelan V, et al. (2007) Determining standard liver volumes: assessment of existing formulae in Indian population. Indian J Gastroenterol 26: 22-25.
[12]. Chan SC, Liu CL, Lo CM, Lam BK, Lee EW, et al. (2006) Estimating liver weight of adults by body weight and gender. World J Gastroenterol 14: 2217-2222.
[13]. Poovathumkadavil A, Leung KF, A Ghamdi HM, Othman Iel H, Meshikhes AW, et al. (2010) Standard formula for liver volume in Middle Eastern Arabic adults. Transplant Proc. 42: 3600-3605.
[14]. **Lui SA, Bonney GK, Kow WCA, Iyer SG, Chang SKY and Madhavan KK** ,Standard Formulae in Predicting Liver Volumes: A Series of Adult Living Donors ,J Transplant Technol Res 2016, 6:1
[15]. DeLand FH, North WA (1968) Relationship between liver size and body size.Radiology 91: 1195-1198.

Amel Ahmed Ali Mohammed. "Standard Formulae in Predicting Norms of Sudanese Liver Volume: A CT based study." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 1, 2019, pp 64-69.