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Estimation of Adult Ghana Liver Dimension and Body Parameters

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ABSTRACT

Despite refinements in surgical techniques for liver transplantation, liver size disparity remains one of the most common problems in patients. The general aim of this study is to estimate the size of liver volume and length of the liver in the midclavicular section and also estimate body parameters such as BMI, BSA, and BSI. The height and weight of patients going for abdominal CT were measured. The BSA, BSI and BMI were then calculated and compared to other measurements. Using MeVisLab software each patient liver volume was measured from their CT images.

Keywords : Liver volume, MeVisLab, BSI, BMI, BSA

I. INTRODUCTION

The production of human voxel models has increased dramatically in recent years with models appearing in literature in the last 11 years from 2003 to 2013, all these models are specific for North Americans, Europeans and Asians populations. Patrizio et al, 2013, have stated that it is uncommon to find models formulated for Africans. Clinicians working in Africa have had to rely on these existing liver sizes for their clinical work even though there is a chance that the shape and volume derived from an African voxel model may be different from the existing voxel models from other races. This assumption is based on the fact that the existing research models have some amount of differences between them, for instance the Americans, Europeans and the Asians models are different from each other, and so will the African model be expected to be. Hence, the need to estimate liver model to represent Ghanaian setting and can be used by our clinicians.

It is a complex organ so the liver can experience a range of problems. A healthy liver functions very productively. However, a diseased liver on the other hand can have many consequences can be dangerous or even fatal.
In view of this estimating the size of the liver can be used as an index to monitor various aspects and stages of liver diseases.

Subjects were patients of the Korle Bu Teaching hospital (KBTH), Cape Coast Teaching hospital (CCTH) and Supreme Specialist Center (SSC). These patients were 18 years and above and of Ghanaian decent. These subjects have no history of liver illness or any other illness that could affect the liver anatomy in anyway.

Ethical clearance was sought from the University of Cape Coast Institutional Review Board (UCCIRB)

II. METHODS AND MATERIAL

The materials and equipment used were;

- Computed Tomography machines
- MeVisLab software
- CT abdominal images
- Microsoft excel software

Patient selection

Data was collected from 92 patients coming for CT scan and analysed after they have read through the ethical clearance form and have signed their consent. Inclusion criteria were: (1) a healthy adult, aged 18 years and above; (2) have no history of liver disease;

Clinical data

For each patient, data taken was age, sex, body height (H) and body weight (BW). The weight and heights of each patient was measured using the digital personal weight scale and tape measure respectively as shown in fig 1 and 2.

The BMI, BSA and BSI were calculated using the following formulas;

Body Mass Index (BMI) = BW/H^2;

BSA (m2) = BW (kg) $^{0.425}$ × BH (cm) $^{0.725}$ × 0.007184 and Body Surface Index (BSI) = $BW/(BSA)^{1/2}$

Figure 1. Weight of patient being taken

Figure 2. Height of patient being taken

The patient goes in for the CT abdominal scan as shown in figure 3. The CT images are then copied on an encrypted external disk.

Figure 3. Patient undergoing CT abdominal scan

Table 1 shows the range of values used for the various patients during the abdomen scan.

Measure of liver volume

In determining the volume of a patient liver, three parameters were used; the number of volume elements (voxels), pixel area of the voxels and slice thickness of the voxels.

In calculating the number of the voxels in the liver image, the axial CT scan images and the MeVisLab software were employed.

The axial CT images was loaded into the MeVisLab software. Mostly the first organ that appears on the first axial slice is not the liver so the images was scrolled down until the first liver image slice appeared. The computer cursor was placed at the edge of the liver at any point and manually traced carefully along the boundaries of the liver in a cross-wise direction still the initial starting point was met again. The MeVisLab software automatically colours the region within the trace area blue as shown in figure 4 labelled A. The numerical value for number of voxels as shown in figure 4 labelled B is recorded. For this patient, the number of voxels for that particular slice was 25240. This process was repeated for all the axial slices that contain liver image till the last liver image was seen. The number of voxels values for a patient was recorded and summed up with the help of Microsoft excel.

TABLE 1. ABDOMINAL CT SCAN PARAMETERS

Scan parameters	Values
Collimation	0.625-7.00 mm
Table Speed	50.5-60.5 mm/rotation
Rotation Time	0.5-0.8 seconds
Voltage	100 - 120 kV (peak).
Body Part Examined	ABDOMEN
Scan Options	HELICAL_CT
Slice Thickness	5.0 – 10mm
Exposure Time	500s
X-Ray Tube Current	80-253A
Exposure	25-126
Filter Type	LARGE
Generator Power	9
Focal Spots	0.8-1.6
Estimated Dose Saving:	0-55.51
Spiral Pitch Factor	0.813
Exposure Modulation Type	3D
Pixel Spacing	0.500 - 0.999
Window Center	40
Window Width	400

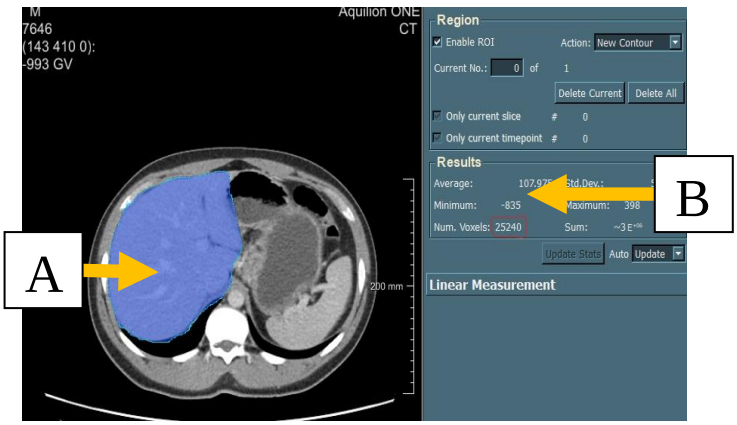

Figure 4. ROI around the measured liver

The pixel area was obtained by finding the square of the pixel spacing. The pixel spacing was obtained by

scrolling to the patient and image section of the CT images which were the first two (2) slices from abdomen CT images as shown in fig. 5 labelled C. From fig 5, the pixel area for the patient is (0.604*0.604 = 0.365 mm^2)

The slice thickness (height of the voxel) was obtained by also scrolling to the patient and image section of the CT images which were the first two (2) slices as shown in figure 6 labelled D. The slice thickness for this patient was 5.0 mm.

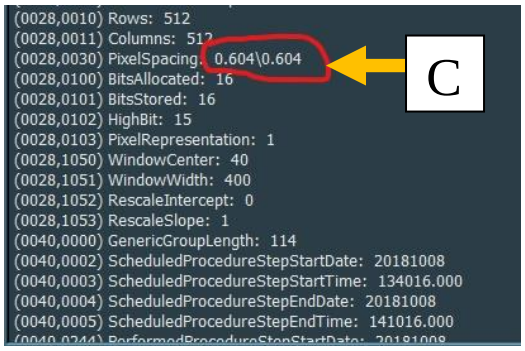

Figure 5. CT image showing pixelspacing

Figure 6. CT image showing the slice thickness

In determining the volume of the liver, the pixel area (the product of pixel spacing) was multiplied by the slice thickness (the height of the voxel) to obtain the volume of a single voxel, this is then multiplied by the total number of voxels, and this is expressed mathematically as:

L_v = (pixel area*slice thickness)*total number of voxels

Volume of a single voxel

where L_v is the volume of liver.

III.RESULTS AND DISCUSSION

Table 2 indicates that the average age for this study is 47.92 ± 30.29 years and 52.83 ± 32.15 years for male and female respectively. The maximum and minimum age for the males was 79 years and 19 years with 85 years and 18 years being the maximum and minimum ages for the females.

The average height for this study for male and female is 1.66 ± 0.29 m and 1.59 ± 0.20 m respectively. The maximum height for male and female is 1.93 m and 1.74 m respectively whereas the minimum height for male and female is also 1.05 m and 1.30 m respectively.

The average weight for this study for male and female is 72.43 ± 27.05 kg and 72.61 ± 34.12 kg respectively. The maximum weight for this study for male and female is 110.90 kg and 109.20 kg respectively. The minimum weight for this study for male and female is 50.80 kg and 37.70 kg respectively.

The average BMI for this study for male and female is 27.18 ± 19.64 kg/m^2 and 29.10 ± 15.56 kg/m^2 respectively. The maximum BMI for this study for male and female is 74.10 kg/m^2 and 53.42 kg/m^2 respectively. The minimum BMI for this study for male and female is 17.01 kg/m^2 and 15.56 kg/m^2 respectively.

The mean BSA for this study for male and female is 1.80 ± 0.38 m^2 and 1.74 ± 0.42 m^2 respectively. This means the body surface of the male patients used for

this study were broader than the female patients. The maximum BSA for this study for male and female is 2.26 m^2 and 2.13 m^2 respectively. The minimum BSA for male and female is 1.36 m^2 and 1.21 m^2 respectively.

The mean BSI for this study for male and female is 53.88 ± 16.38 kg/m and 54.67 ± 20.45 kg/m as shown. The maximum BSI for this study for male and female is 73.82 kg/m and 74.82 kg/m respectively. The minimum BSI for this study for male and female is 40.52 kg/m and 33.74 kg/m respectively.

TABLE 2
VARIOUS MEASURE AND CALCULATED BODY PARAMETERS

Sex	**Measure**	**V_L (L)**	**Midclavicular line (cm)**
Male	Min	0.763	11.0
	Max	2.371	22.0
	Mean	1.356	15.7
Female	Min	0.584	12.0
	Max	2.864	23.0
	Mean	1.363	15.9

Table 3 shows the summary of the calculated values for the volume and length of liver in the midclavicular line in terms of gender. The mean liver volume for this study for male and female is 1.356 ± 0.744 L and 1.363 ± 0.845 L respectively. The maximum liver volume for this study for male and female is 2.371 L and 2.864 L respectively. The minimum liver volume for this study for male and female is 0.763 L and 0.584 L respectively.

TABLE 3. LIVER VOLUME AND LENGTH OF LIVER IN THE MIDCLAVICULAR LINE

Sex	measure	Age (yrs)	Weight (kg)	Height (m)	BMI (kg/m^2)	BSA (m^2)	BSI (kg/m)
Male	Max	79.00	110.90	1.93	74.10	2.26	73.82
	Min	19.00	50.80	1.05	17.01	1.36	40.52
	Mean	47.92	72.43	1.66	27.18	1.80	53.88
Female	Max	85.00	109.20	1.74	53.42	2.13	74.82
	Min	18.00	37.70	1.30	15.56	1.21	33.74
	Mean	52.83	72.61	1.59	29.10	1.74	54.67

It also indicates that the length of liver in the midclavicular line (or as commonly known as the span of the liver) for females was slightly higher than that of males. This was also expected as the mean female liver volume was larger than that of the males.

Research studies performed by Chouker et al and Wolf (Choukèr et al., 2004; Wolf, 1990) show that the female liver size is normally smaller in size than that of males but results from this study indicates otherwise.

This abnormally is explained by the fact that 49 % of the female patients used were obese and studies by Grante et al (Grant et al., 2020) indicates that obese persons tend to have liver sizes about 50 % - 100 % larger than persons with normal BMI.
This also explains why the length of the liver in the midclavicular line is longer in females than in males.

able 4 also indicates that the results from this study is different from that of ICRP, this particular results was expected as indicated by studies performed by (Govender, Lazarus, De Gama, & Satyapal, 2017). This study indicates that organ mass is influenced by several demographic parameters and environmental conditions, and they differ among populations. Since volume is a function of mass, it presupposes that it is also influence by these same factors.

Table 5 indicates the various body parameters from this study and that of the ICRP for both the Asian and European populations.

TABLE 4
LIVER SIZE FROM THIS STUDY COMPARED WITH THAT OF THE ICRP

Gender	This study (L)	ICRP (2002) (L)
Male	1.356	1.714
Female	1.363	1.333

TABLE 5
BODY PARAMETERS FROM THIS STUDY COMPARED WITH THAT OF THE ICRP (ASIAN AND EUROPEAN POPULATION)

Parameter	**This study (2019)**	**ICRP-Asian (1998)**	**ICRP-European (2015)**
Male			
Age (years)	47.92(19-79)	35(20-50)	42(20-80)
Race	African	Mongoloid	Caucasoid
Weight (kg)	72.43	60.00	76.00
Height (m)	1.66	1.70	1.79
BMI (kg/m^2)	27.18	22.00	24.00
BSA (m^2)	1.80	1.78	1.95
BSI (kg/m)	53. 88	33.71	38.95
Female			
Age (years)	52.83(18-85)	35.00(20-50)	42.00(20-50)
Race	African	Mongoloid	Caucasoid
Weight (kg)	72.61	51.00	63.00
Height (m)	1.59	1.60	1.65
BMI (kg/m^2)	29.10	22.00	23.00
BSA (m^2)	1.74	1.55	1.67
BSI (kg/m)	54.67	32.90	35.20

IV. CONCLUSION

The mean Liver volume for the male and female adult for this study was 1.356 L and 1.363 L respectively. It shows that the measured female liver volume for this study is bigger than that of the male. This was compared with the ICRP reference for liver which was 1.714 L and 1.333 L for male and female respectively.

The length of the liver in the midclavicular line. With this, the average length recorded was 15.70 ± 2.31 cm and 15.90 ± 2.53 cm for male and female respectively. The body parameters for this study were different for both Asian and European populations.

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