ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES

SCHOOL OF MEDICINE

DEPARTMENT OF CLINICAL RADIOLOGY

CT scan evaluation normal liver, spleen, and kidney size parameters in adults at TASH, Addis Ababa, Ethiopia: an institutional-based cross-sectional prospective study

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A Thesis Submitted to the Department of Clinical Radiology of Addis Ababa University in Partial Fulfillment of the requirements for the specialization Degree in Clinical Radiology

ACKNOWLEDGMENT

I would like to thank AAU, School of Medicine, Department of Radiology, giving me a great opportunity to do this research. My deepest gratitude goes to my advisors TesfayeKebede (MD, Abdominal Imaging Subspecialist, Assot. Professor of Radiology) who gave me help in the whole process of my thesis for their day to day supervision and guidance in my work and his unlimited support.

I would like to thank also the black lion hospital CT unit, nurses, and radiology technologist for helping in data collection

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Abstract

Introduction: Liver, spleen, and kidney size can be affected by different diseases so, well-established measurements of the actual size of those organs are mandatory. Computed tomography is one imaging modality that measures the sizes of the internal organs accurately.
Objective: The main aim of this study was to determine the normal liver, spleen, and kidneys size parameters and their correlation with demographic factors on abdominal CT scans in adultswho visited TASH, Addis Ababa, Ethiopia

Methods: a prospective hospital-based cross-sectional study was done from June 24-December 28, 2020 in adults who visited TASH. Non-probability, the convenience study design was used. Data were collected from consecutive eligible adults who came for abdominal CT scans in the study period, using interviewer-administered structured questionnaires. A total of 1008 abdominopelvicCT was examined and 164 adults (117 for liver, 124 for kidney, and 147 for spleen) were selected for this study based on inclusion and exclusion criteria.Different linear measurements of the liver, spleen, and kidneys were taken and the volume of those organs was calculated from the linear measurements. The data was cleaned and analyzed using SPSS version 26.0. Student t-test and Pearson correlation were used to perform statistical analysis and the results were presented using tables and figures.

Results: The mean volume of the liver, spleen, right kidney, and left kidney were 1089.33 cm3 ± 257.73 mc3, 195.82 cm3 ± 84.72 cm3, 106.62±28.88 cm3, and 115.02 ±28.51 cm3 respectively. The mean maximum CC length, MHP CC length, the MHP AP diameter, and the maximum transverse diameter of the liver were found to be 14.88 ±1.94, 10.21± 1.73, 14.99 ±1.85, and 15.71 ± 2.19 respectively. The mean maximum length, width, and thickness of the spleen were 9.53 ± 1.53, 9.10±1.42, and 4.18 ± 0.91 respectively. The mean maximum length, width, and depth of the kidneywere 9.83±1.02, 4.66±0.56, & 4.48±0.47 and 13±1.04, 4.84±0.58, & 4.43±0.49 on the right and left side respectively. The volume of the liver, the right kidney, and the left kidney were positively correlated with the height, weight, BMI, and BSA of patients. Splenic volume was also positively correlated with the weight, height, and BSA of the participants. The age of the patients was significantly negatively correlated with the liver and left kidney volume.
Conclusion: The mean volume of the liver, spleen, and kidney were highly correlated with body habitus including height, weight, and BSA. There was a significant decrement in the size of the liver and kidney with aging.

ronyms /Abbreviations

AAU	Addis Ababa university
AP	Anteroposterior
BMI	Body Mass Index
BSA	Body Surface Area
CHS	College of health sciences
CC	Craniocaudal
HTN	Hypertension
MPH	Midhepatic point
MRI	Magnetic resonance imaging
SD	Standard deviation

1. Introduction

Liver, spleen, and kidney size can be affected by different diseases; can be grouped into tumors, infiltrative diseases, infectious diseases, hematologic disorders, autoimmune and metabolic disorders, toxic and drug-related causes (1, 2). Accurate measurements of those organs are very important, and different methods can be used like physical examination with palpation and percussion to estimate liver and spleen size may not be accurate.

Various methods of radiographic examination may be used such as plain radiography, ultrasound, CT; proton emission computed tomography (PET) and MRI can be used. Ultrasound is also the primary imaging to accurately estimate the size of the liver, spleen, and kidneys which is cheap and used at the bedside. Though, having those advantages it is operator dependent and may not be taken at the same level repetitively (1, 3, 4). CT has been used to determine liver, spleen, and kidney volumes/sizes; there is a need to further identify a technique that is practical and accurate to determine the liver, kidney, and spleen size while reporting a routine abdominal CT scan because of obtaining volumes is time-consuming and not practical for daily reporting.

With the increasing use of abdominal CT for the evaluation of various abdominal pathologies involving the liver, spleen, and kidney, it is important to have well-established parameters that can accurately determine the size of those internal organs.

Although, knowing the exact size of the major internal abdominal organs is crucial, there are no well-established single measurement parameters to determine the exact size. False-positive labeling of a patient as having organomegaly can lead to unnecessary medical tests, anxiety as well as healthcare expenditure

In many litterateurs and studies, there is variation in the linear as well as volume size measurements in the body organs depending on the body habitus likely weight, BMI, BSA, and gender. Until now, there was no study done CT scan size parameter measurement in the liver, spleen, and kidney in our country.

2. Rationale of the study

Manydisease entities including infectious, neoplastic, hematologic, and metabolic causes which could affect the size of the visceral organs are common in our daily evaluation of patient abdominal CT scans. To accurately diagnosis organomegaly as well as kidney size atrophy knowledge of the normal valueand accurate measurements of the normal size of the liver, spleen, and kidney is mandatory. So, the main significance of this study was to determine individual linear measurements, as well as combinations of measurements of liver, spleen, and kidneys among Ethiopian individuals, which used to as entery point for further studies to establish a reference value for routine CT scan reporting. This study also aimed to assess the relationship of individual linear measurements of the spleen, kidney, and liver with the volume of those organs which might help to use single linear measurements for routine daily abdominal CT evaluation.

3. Objectives

3.1 General objectives

- To determine the normal liver, spleen, and kidneys size parameters and their correlation with demographic factors on abdominal CT scan in adultswho visited TASH, Addis Ababa, Ethiopia
- To determine the relation of the unidimensional(linear) size measurements with the liver, spleen, and kidney volumein adultswho visited TASH, Addis Ababa, Ethiopia

3.2 Specific objective

- To determine the normal size measurements of liver on abdominal CT in the adult population and its relation with the demographics data in adults who visited TASH, Addis Ababa, Ethiopia
- To determine the normal size measurements of spleen on abdominal CT in the adult population and its correlation with the demographic data in adults who visited TASH, Addis Ababa, Ethiopia
- To determine the normal renal size on abdominal CT in the adult populationand its correlation with the demographics data who adults who visited TASH, Addis Ababa, Ethiopia
- To determine the correlation linear liver, spleen, and kidney measurements with the volume of liver, spleen, and kidney respectively in adults visited TASH, Addis Ababa Ethiopia.

4. Methods and materials

4.1 Study design

An institution-based cross-sectional, prospective study design was conducted to assess the normal size parameters of the liver, spleen, and kidneys on abdominal CT scan of Ethiopian adults visiting TASH, Addis Ababa, Ethiopia

4.2 Study area and period

The study was conducted at TASH, from June 24, 2020 - December 28, 2020. TikurAnbessa Specialized Hospital (TASH) is located in Addis Ababa which is the capital city of the country. It is the largest & oldest public hospital in the country providing a high level of clinical care for millions of people and training to health science students from different parts of the country and the Horn of Africa. The hospital was selected for this study because it provides service for large size of the population from each corner of the country and verities of imaging modalities including CT, ultrasound, and MRI is performed. The Imaging department of TASH is among the most commonly visited imaging units in the country. On average, at least one thousand CT-scan imaging was done per month of which around 300 were abdominal CT scans. Even though many of the patients are scanned for abdominal CT for a different indication, there was no organized liver, spleen, and kidney size parameters measurement documented in the reports.

4.3 Source population

The source population for this study was all Ethiopian adults referred from any unit of the hospital for routine diagnostic abdominal CT scan

4.4 Study population

The study population for this study was all eligible adult patients referred from any unit of the hospital for routine diagnostic abdominal CT scan during the study period which does not indicate liver, spleen, or kidney lesions.

4.5 Inclusion and exclusion criteria

4.5.1 Inclusion criteria

- All adult clients (age >/= 18 years old) who undergo post-contrast abdominal CT scan examination at TASH, with no significant abnormities and no condition known to involve the liver, spleen, or kidneys

4.5.2 Exclusion criteria

- Clients too ill to allow measuring weight and height or to take informed consent
- Subjects whose CT scans had abnormal features, such as skin defects, bilaterally cutoff edges, or movement artifacts that could influence the various measurements of this study
- All patients with significant focal lesions in the liver, spleen, or kidneys, i.e. any focal lesions other than small haemangiomas or simple cysts
- Lymphoproliferative disorder and hematologic malignancy that may affect organ size
- Visceral organ transplantation.
- Subjects having congestive heart failure
- Known Cirrhotic patient or patient having portal HTN.
- History of known kidney or lower urinary tract disease or a related indication for the examination
- renal morphologic anomalies (such as horseshoe kidney or ectopic kidney)
- unilateral or partial nephrectomy
- hydronephrosis

4.6 Sampling procedure and sample size determination

Conveniencenon-probability sampling, utilizing inclusion and exclusion criteria were used. All of the patients which undergo post-contrast abdominal CT scan examination at TASH, with no significant abnormities and no condition known to involve the liver, spleen, or kidneys are included in the study, and their demographic data including age, gender, height, weight, BSA and BMI was filled at the time of when the CT image was taken, and the image is reviewed after the examination to look for any exclusion criteria. The sample size of this study was determined by the number of patients who were available at the period of the study which fulfilled the inclusion criteria, so all clients having post-contrast abdominal CT which has no exclusion criteria were included from June 24, 2020- December 28, 2020.

4.7 Study Variables

4.7.1 Dependent variable

- Liver maximum CC length
- Liver MHP CC length
- Liver maximum MHP AP diameter.
- Liver maximum transverse diameter
- Liver volume
- Spleen length
- Spleen width
- Spleen thickness
- Spleen volume
- Kidney length
- Kidney width
- Kidney depth
- Kidney volume

4.7.2.Independent variables

- Demographic characteristics such as sex, age, weight, height, BMI, and BSA

4.8 Operational definition

- **MHP(mid-hepatic point) -** defined as halfway between the mid vertebra and right lateral margin of the liver at the level of the main portal vein on a transverse section
- **Midhepaticcraniocaudal (MHP CC) length of the liver-** stands for the craniocaudal measurement of the liver from the dome of the diaphragm to the lower tip of the liver on the coronal image at MHP
- **Maximum CC length –**stands for the maximum craniocaudal length of the liver from the dome of the diaphragm to the tip of the liver at any point.
- **MHP AP diameter of the liver-** refers to the maximum anteroposterior measurement of the liver at the level of the MHP on the axial image.
- **Transverse diameter of the liver-** refers to the maximum transferee measurement pass through the right and left lobe of the liver at the level of the main portal vein.

- **Liver volume-** calculated by the formula by 0.31*Max.CC length*max.AP diameter *max. transfers diameter)
- **Length of the spleen –** refers to the maximum craniocaudal measurement parallel to the splenic axis on coronal image
- **Width of the spleen-** refers to the maximum anteroposterior measurement on transverse image
- **The thickness of the spleen-** refers to the maximum dimensionof the spleen from the hilum to the outer convex surface on the transverse image
- **The volume of the spleen-** calculated manually by using the standard clinical prolate ellipsoid equation for spleen [0.524 × splenic indexes (max. length × max. width × max. thickness)
- **Length of the kidney-** refers to the maximum craniocaudal dimension of the kidney on a coronal image
- **Width of kidney –**refers to the maximum outer to the inner dimension of the kidney perpendicular to the length on coronal image
- **Depth of Kidney-**refers to the maximum anterior to posterior dimension of the kidney on sagittal image
- **The volume of kidney-**calculated by the ellipsoid formula (л/6(0.524) * maximum length*maximum width*maximum depth.

4.9 Data collection tools and techniques

Data was collected from the CT scan unit of the Radiology department of TASH for about 06 months started June 24, 2020- December 28, 2020. A structured questionnaire containing closed-ended questions specifically designed for this study was used for data collection. The questionnaire was prepared by reviewing related studies done previously and tried to assess demographic factors and CT scan parameters. The demographic data were directly interrogated from the client after obtaining informed consent while the CT scan findings were documented using a structured checklist.

A total of 1008 post-contrast abdominal CT were done in adults during the study period and evaluated for the exclusion and inclusion criteria. Of those, a total of 164 patients fulfilled the inclusion criteria (117 for liver, 147 for spleen, and 124 for kidney) sizes measurement were included in the study.

4.10 CT scanning techniques and measurement

4.10.1 CT scanning technique

The protocol for the CT scans of the abdomen included administration of intravenous contrast media, followed by arterial phase images till the inferior margin of the liver and venous phase images through the entire abdomen and pelvis. The scan was performed with 64 slice GE optima 660CT with a scan time of 0.6 seconds and a slice thickness of <= 5 mm. To minimize motion artifacts, patients will be instructed to breathe at full inspiration and hold his/her breathe for 1 s during real-time scanning.The original series of post-contrast abdomen CT which are taken with a slice thickness of </= 5 mm was be sent to the PACS (picture archiving and communication system) workstation and images were reviewed by scrolling on the workstation.

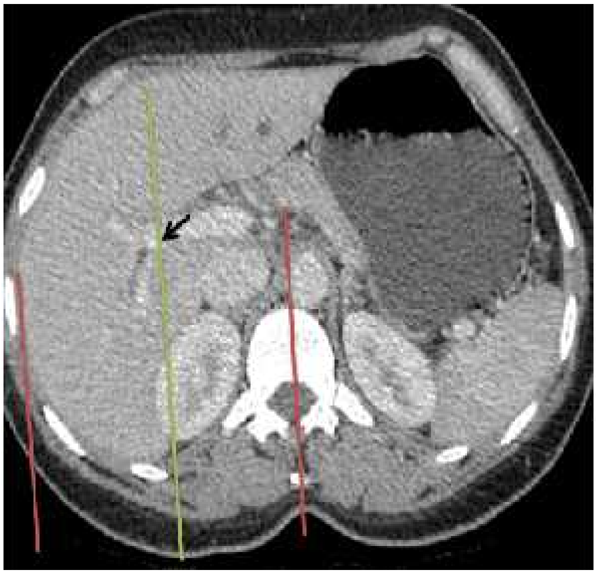
4.10.2 Measurements

4.10.2 .1 Liver measurements

The post-contrast abdominopelvic CT of patients which fulfill the inclusion criteria was revised on DICOM RadiAnt and the following linear liver dimensions measurements were included: midhepatic point craniocaudal(MHP CC) length, maximum CC length to tip of liver, maximum transverse diameter, and MHP anteroposterior (AP) diameter of the liver.

The plane of the horizontal component of the main portal vein was identified and used as a reference point for measurements. The MHP was defined as halfway between the mid vertebra and right lateral margin of the liver at the level of the main portal vein on a transverse section (Fig.1). MHP CC was defined as a perpendicular measurement on the coronal images from the hepatic dome to the inferior margin of the liver passing through the midhepatic point (Fig. 3). The maximum craniocaudal length was defined as the greatest obtainable craniocaudal dimension of the liver from the hepatic dome to the liver tip on coronal reconstructed images (Fig. 3). The maximum transverse diameter was the maximum measurement from the right to left margins of the liver at the level of the portal vein (Fig. 2). MHP AP measurement was taken at the level of the midhepatic point from the anterior to posterior margin of the liver (Fig. 2) (5, 6).

Liver volume measurements were performed depending on linear hepatic measurements. The shape of the liver is comparable to a tetrahedron and the volume formula of a tetrahedron was used as a starting point with a modification factor of 0.31.
Liver Volume = (MHP AP * Max LL * Max CC * 0.31) in cm3 as proposed by Vermalet al .2010) (5)and Muggli D. et al. 2009(7)



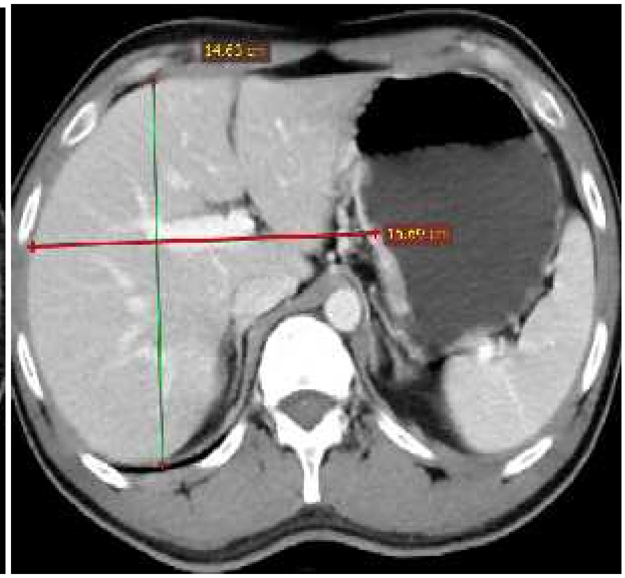


Figure 1(left) axial CT scan of 35 years old woman shows a mid-hepatic point (black arrow) halfway between the mid vertebra and right lateral margin of the liver (red lines). Figure 2(right): showing the linear dimensions of the liver: Maximum transverse dimension (red) is the maximum measurement from the right to left margins of the liver. Mid hepatic point AP (MHP AP) measurement was taken at the level of the midhepatic point from anterior to posterior margin of the liver (green**)**

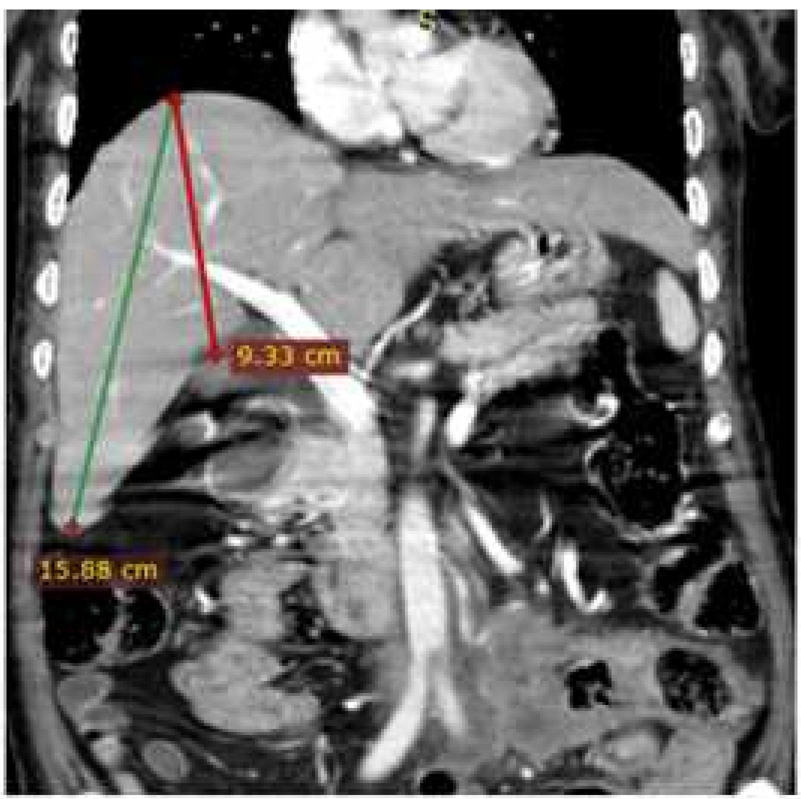


Figure 3: showing the linear dimensions of the liver, the maximum craniocaudal length, and maximum midhepatic CC length

4.10.2 .2 Spleen measurements

The post-contrast abdominal CT of the all in the study period was observed on the PACS system. Spleen was evaluated in each axial section and coronal reconstruction of CT scan images. The maximum length of the spleen was recorded in the coronal section along from the superior border of the spleen to the inferior tip. The maximum Width of the spleen was also recorded as the greatest overall dimension on transverse images and the maximum thickness as the distance between the hilum and the outer convex surface of the spleen [Figure 4]. All dimensions were recorded maximum appreciated in sections for better accuracy (1, 8).

The volume of the spleen was calculated manually by using the standard clinical prolate ellipsoid equation for spleen (0.524 × splenic indexes (max. length × max. width × max. thickness) (8).

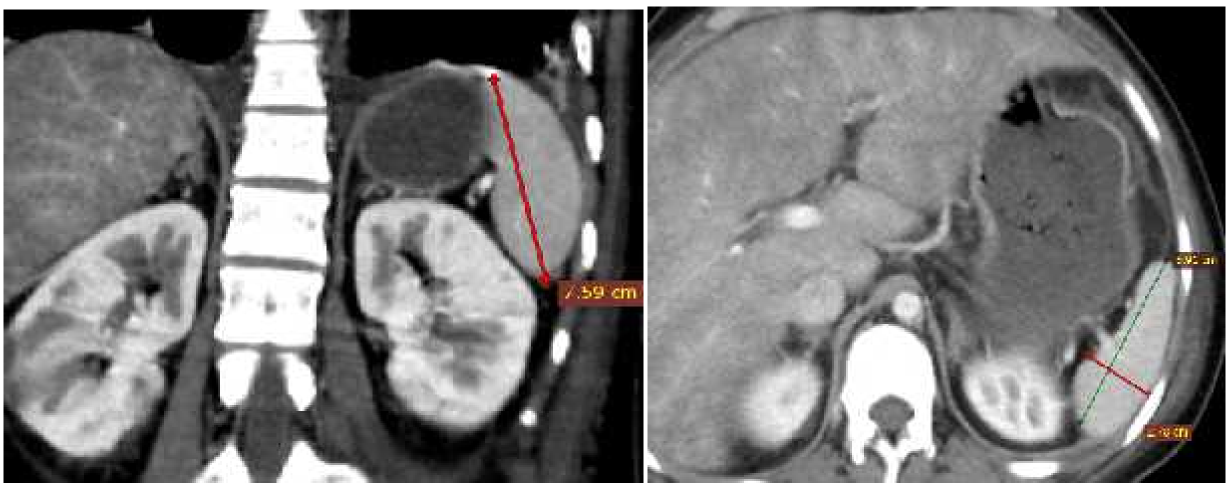


Figure 4: spleen size measurements on the left coronal image showing maximum length and the right axial image showing maximum width and thickness of the spleen.

4.10.2.3 Kidneys size measurements

All patients fulfilling the inclusion criteria having a contrast-enhanced abdominal CT scan are evaluated on a DICOM image viewer. Linear dimensions of the kidney such as renal length (L), renal width (W), and renal depth (D) was measured. Renal length (L) is the maximum longitudinal length of the kidney determined on the coronal slice parallel to the long axis of the kidney. Renal Width (W) will be determined as maximum width perpendicular to the renal length on the identical slice of CT where renal length is localized. Renal Depth (D) will be calculated as the maximum depth of the kidney right-angled to the renal length in a thick sagittal slice of CT scan image. Kidney Volume (V) will be calculated using the formula as Kidney volume (V) =л/6 x L x W x D (look on Figure 5)(9, 10)

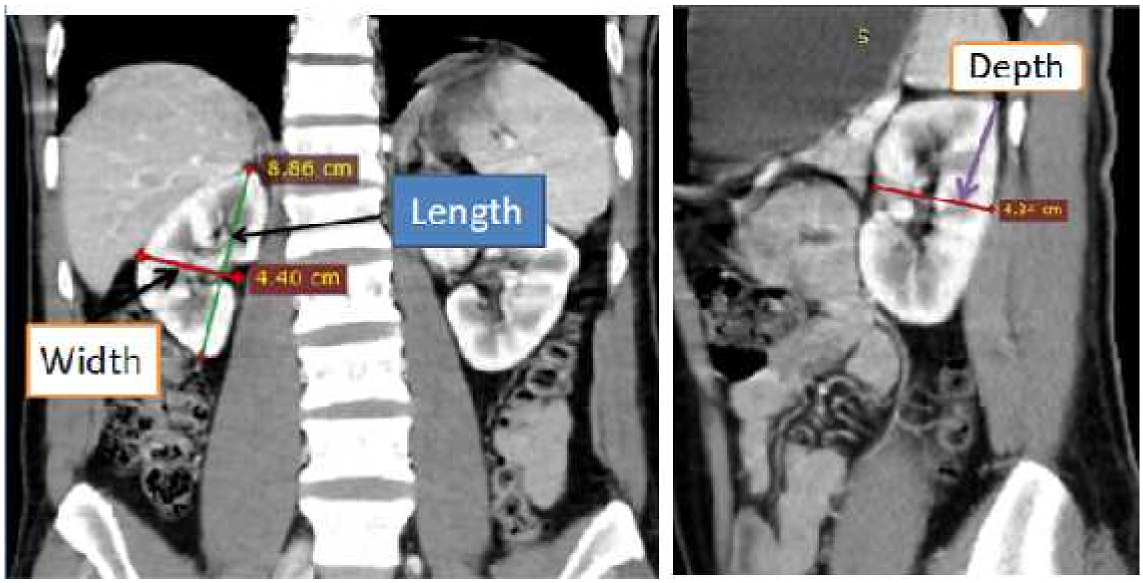


Figure 5: Abdominal CT scan, left coronal image showing length and width and right image s sagittal image showing depth or thickness of kidney

4.11 Methods of data analysis

Data entering, coding, and clearing for the quantitative data was performed using Epi-info version 7.0 and the analysis was done using IBM SPSS version 26.0. Frequency and cross-tabulation were used to check for missed values and variables. The demographic characteristics of participants and the liver spleen, kidney, and spleen size parameters were computed by using simple descriptive statistics (mean, percentage, frequencies, and standard deviation). Pearson correlations were applied to calculate associations of the liver, spleen, and kidney size with the demographic variable, and a student t-test was used to assess the level of correlation.The Pearson correlation was also applied to determine the relation of linear measurements of size parameters with the volume of liver spleen and kidney. P-value of <0.05 and 95% confidence level was used as a difference of statistical significance. Finally, the study finding was presented using diagrams, tables, and figures.

4.12 Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board of the college. A permission letter was submitted to the CT scan unit from the Radiology department & Research Directorate to conduct the study. After this, the introduction & familiarization of the data collectors with the team unit was secured. All the study's participants were informed about the purpose of the study and their right to refuse not to participate in the study, which was then followed by obtaining informed written and verbal consent before administering each questionnaire. Then, the purpose of the study was briefly explained to the respondents and informed consent was maintained. The participants were also well informed that participation should be voluntary and that they could stop the interview at any time without repercussions. The questionnaires were kept anonymous and confidential.

5. Results

5.1 Demographic data

A total of 164 participants were included in this study, of which 99 (60.4%) were females and 65(39.6%) were males (Table-1). The age range of the patients was 18 to 77 years with a mean of 46.93± 13.7 years. The mean weight and height of the study participants were 58.6 ± 11.94 kg and 1.62 ± 0.08 m respectively.

Table1: Demographic data's of 164 study participants at TASH, Addis Ababa, Ethiopia

Variable	Frequency			Percent
Male	65			39.6 %
Female	99			60.4%%
Total	164			100.0%
	N	Minimum	Maximum	Mean±SD
Age (years)	164	18	77	46.93±13.71
weight (kg)	164	35.00	105.00	58.68±11.94
BMI(kg/m^2)	164	13.43	37.59	21.98±4.35
Height (m)	1.64	1.46	1.83	1.64±0.08
BSA(m^2)	164	1.22	2.30	1.62±.183

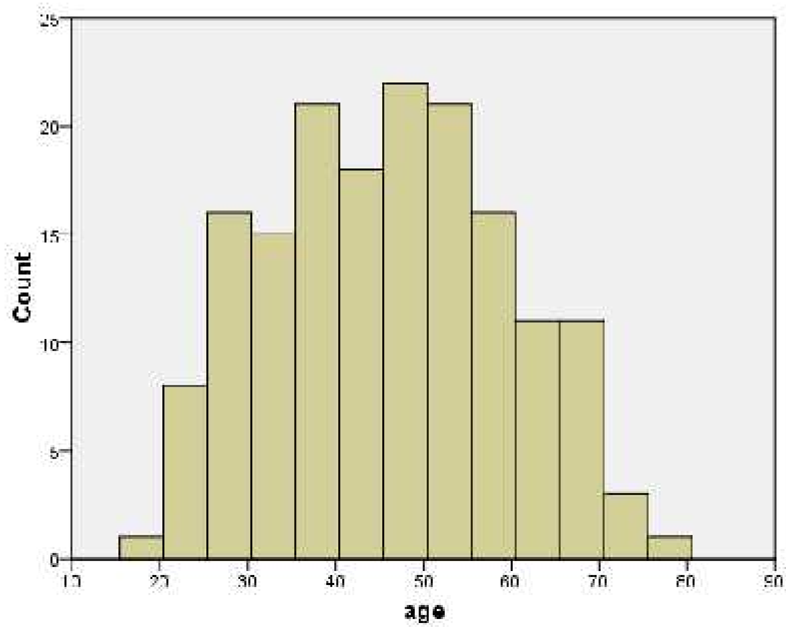


Figure 6: Distribution of the age of the participants

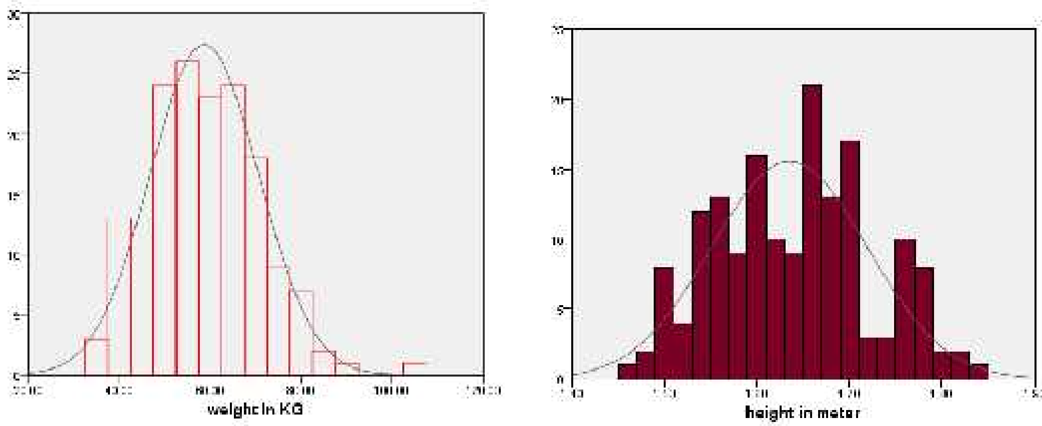


Figure 7: Showing the height and weight distribution of the participants

5.2 Liver volume and unidimensionalsize measurements

5.2.1 Liver volume and unidimensionalsize witha gender distribution

The mean liver volume for total study participates of 117 were 1089.33 cm3 ± 257.73 mc3 (1067.60 cm3 ± 279.95 cm 3and 1099.79 cm3 ± 247.53 cm3 in males and femalesrespectively), the mean volume of females was higher than the male by a value of 32.19 cm3 which was not statistically significant on independent t-test (t-value of 0.65, p-value of 0.529). The mean maximum CC length, MHP CC length, the MHP AP diameter, and the maximum transverse diameter of the liver were found to be 14.88 ±1.94, 10.21± 1.73, 14.99 ±1.85, and 15.71 ± 2.19 respectively (Table-2). The mean value of maximum CC length and the MHP CC length was slightly higher in females than males and the MHP AP diameter of the liver was slightly higher in males, but the mean maximum transverse diameter of the liver appeared to be near similar in both gender.

Table 2: Showing Liver volume and one-dimensional measurements mean, standard deviation, minimum and maximum values with gender distribution in a total of 117 study participants of TASH, Addis Ababa, Ethiopia

Variables		No.	Minimum	Maximum	Mean±SD
Liver volume	Male	38	616.56	1668.50	1067.60±279.95
	Female	79	452.47	1750.92	1099.79±247.53
	Total	117	452.47	1750.92	1089.34±257.73
Maximum CC-length (cm)	Male	38	10.02	17.81	14.03 ± 1.99
	Female	79	9.63	18.88	15.28 ± 1.79
	Total	117	9.63	18.88	14.88 ±1.94
MHP CC length(cm)	Male	38	6.29	13.55	9.46 ± 1.71
	Female	79	7.47	14.57	10.57 ± 1.64
	Total	117	6.29	14.57	10.21±1.73
Maximum AP diameter MHP(cm)	Male	38	9.65	19.15	15.62 ±1.97
	Female	79	10.47	17.91	14.70 ± 1.72
	Total	117	9.65	19.15	14.99 ±1.85
Maximum transverse diameter (cm)	Male	38	11.69	20.46	15.65± 2.18
	Female	79	10.54	20.58	15.74 ± 2.20
	Total	117	10.54	20.58	15.71 ±2.19

5.2.2 Correlation of liver volume andunidimensionalsizes with demographics data

A positive correlation was seen between the liver volume and weight, BMI, height, and BSA as seen in [Table 3]. The age of the participants had a significant negative correlation with the liver volume, the maximum CC length, and the MHP CC length. There was a mild positive correlation between the height of the patient and the maximum CC length of the liver at any point on the coronal image(r=0.191, p-value=0.039). There was no significant correlation between height, weight, BSA, and BMI of the patient and MHP CC length. There was a positive correlation between the maximum anteroposterior diameter of the liver at MHP with the weight, height, BMI, and BSA of the participants (Table-3). There was a positive correlation between the maximum transverse diameter through the right and left lobe and the height of the patient (r= 0.202, p-value=0.029), otherwise there was no significant correlation with other parameters.

Table 3:Showing liver volume and one-dimensional measurements correlation with demographic data in a total of 117 study participants of TASH, Addis Ababa, Ethiopia

		Age	weight	height	BMI	BSA
Liver volume	Pearson Correlation	-0.317**	0.374**	0.249**	0.233*	0.387**
	P-value	<0.001	<0.001	0.007	0.012	<0.001
Maximum CC-length	Pearson Correlation	-0.351**	0.161	-0.066	0.191*	0.130
	P-value	<0.001	0.083	0.482	0.039	0.161
MHP CC length	Pearson Correlation	-0.278**	0.103	-0.099	0.155	0.070
	P-value	0.002	0.267	0.286	0.096	0.451
Maximum AP diameter	Pearson Correlation	-0.059	0.487**	0.307**	0.324*	0.515**
	P-value	0.524	<0.001	0.001	<0.001	<0.001
Maximum Transverse diameter	Pearson Correlation	-0.175	0.032	0.202*	-0.075	0.063
	P-value	0.059	0.733	0.029	0.424	0.499

5.2.3 Correlation between liver volume and linear dimension measurements (indexes)

Among the unidimensional indexes of the liver, the maximum craniocaudal length on the coronal image from the dome of the diaphragm showed the best correlation with liver volume (r=0.636).The next best correlation was the transverse diameter of the liver (r=0.634).

Table 4: Showing liver volume correlation with unidimensional size measurements.

		CC-length	MHP CC length	MHP AP diameter	Tansversediameter
Liver volume	Pearson Correlation	0.636**	0.394**	0.546**	0.634**
	P value	<0.001	<0.001	<0.001	<0.001
	N	117	117	117	117

5.3 spleen volume and unidimensionalsizes measurements

5.3.1 Spleen volume and unidimensional size mean value with a gender distribution

The mean volume of the spleen in 147 total study participants was 195.82 cm3 ± 84.72 cm3 (211.83 cm3 ± 85.75 cm 3 and 186.25 ± 83.10 cm3 in males and females respectively) (Table-5), which showed the mean volume of the spleen in males was about 11.8 % higher than females but it was not statistically significant with t-value of 1.75, the p-value of 0.079. The mean maximum length, width, and thickness of the spleen were 9.53 ± 1.53, 9.10±1.42, and 4.18 ± 0.91 respectively. All linear spleen measurements were slightly lower in females than males.

Table 5: Showing spleen volume and unidimensional size measurements in a total of 147 study participants

Variables		No.	Minimum	Maximum	Mean±SD
Spleen volume	Male	55	74.65	432.78	211.83±85.75
	Female	92	60.69	440.99	186.25±83.09
	Total	147	60.69	440.99	195.82±84.72
Maximum Spleen length (cm)	Male	55	6.83	13.17	9.86 ±1.63
	Female	92	6.01	12.94	9.33 ±1.44
	Total	147	6.01	13.17	9.53 ± 1.53
Maximum spleen width (cm)	Male	55	6.14	11.96	9.18 ±1.47
	Female	92	5.90	13.25	9.04 ±1.40
	Total	147	5.90	13.25	9.10±1.42
Maximum spleen thickness(cm)	Male	55	3.00	6.74	4.40 ± 0.88
	Female	92	2.45	6.53	4.06 ±0.91
	Total	147	2.45	6.74	4.18 ± 0.91

5.3.2 Correlation of spleen volume and unidimensional size with the demographic data

There was a statistically significant positive correlation between spleen volume and weight, height, and BSA, however, the rest of the parameters did not correlate significantly with spleen volumes. A positive correlation was seen with spleen volume and BMI, however, it was not statistically significant (p=0.261). A negative correlation was seen with spleen volume and age, however, it was not statistically significant (p=0.390). There was a statistically significant positive correlation between the height, weight, and BSA of the participants and the maximum length of the spleen on the coronal image. The maximum width of the spleen on the axial image was positively correlated with the weight, BMI, and BSA of the participants. There was also a significant positive correlation between body height and the maximum thickness of the spleen.

Table 6: Showing splenic volume and unidimensional size measurements correlation with demographic data in a total of 147 study participants of TASH, Addis Ababa, Ethiopia

			Age	weight	height	BMI	BSA
Spleen volume		Pearson Correlation	-0.071	0.214^{**}	0.093	0.230^{**}	0.248^{**}
		P-value	0.390	0.009	0.261	0.005	0.003
Maximum Splenic length		Pearson Correlation	-0.076	0.247^{**}	0.215^{**}	0.128	0.277^{**}
		P-value	0.358	0.003	0.009	0.123	0.001
Maximum spleen width		Pearson Correlation	-0.103	0.323^{**}	0.159	0.234^{**}	0.333^{**}
		P-value	0.212	<0.001	0.054	0.004	<0.001
Maximum spleen thickness		Pearson Correlation	-0.008	0.065	0.233^{**}	-0.052	0.111
		P-value	0.928	0.436	0.004	0.531	0.183

5.3.3 Correlation between Splenic volume and one-dimensional measurements

Among the unidimensional indexes, the maximum spleen thickness on axial images showed the best correlation with splenic volumes (r=0.803) and the maximum spleen length on coronal images showed the next best correlation with splenic volumes (r=0.788)

Table 7: Correlation between Splenic volume and unidimensional splenic sizes.

		Maximum Splenic length	Maximum spleen width	Maximum spleen thickness
Spleen volume	Pearson Correlation	0.788^{**}	0.759^{**}	0.803^{**}
	P value	<0.001	<0.001	<0.001
	N	147	147	147

5.4 kidneys volume and unidimensionalsize measurements

5.4.1 Kidneys volume and unidimensionalsize witha gender distribution

The mean volume for the right kidney and left kidney in 124 of the study population were 106.62±28.88 cm3 (116.64 ± 29.02 cm3 in males & 99.62± 26.82 cm3in females) and 115.02±28.51 cm3 (125.34± 26.60 in male & 107.94 ± 27.68 in females) respectively. Both the right kidney and the left kidney were higher in males than females with a mean difference of 17.02 &17.38 cm3 respectively which was significant with t-value of 3.36 and 3.50, p-value = 0.001 in both of them. The left kidney was larger than the right kidney, and was statistically significant with (t-value 5.32, p-value<0.001). The mean maximum length, width, and depth of the right kidneywere 9.83±1.02, 4.66±0.56, and 4.48±0.47 respectivelyand it was 10.13±1.04, 4.84±0.58, and 4.43±0.49 respectively on the left side.

Table 8:Showing right and left kidney volume as well as unidimensional size measurements with gender distribution in 124 study participants of TASH, Addis Ababa, Ethiopia

Variables		No.	Minimum	Maximum	Mean ±SD
Right kidney volume (cm^3)	Male	51	73.15	193.47	116.64±29.02
	Female	73	51.51	205.70	99.62±26.82
	Total	124	51.51	205.70	106.62±28.88
Right kidney length (cm)	Male	51	8.02	12.47	10.02±1.02
	Female	73	8.02	12.60	9.69 ±1.01
	Total	124	8.02	12.60	9.83±1.02
Right kidney width (cm)	Male	51	3.44	6.43	4.74 ± 0.60
	Female	73	3.43	5.64	4.44 ±0.50
	Total	124	3.43	6.43	4.66±0.56
Right kidney depth (cm)	Male	51	3.94	6.05	4.64 ± 0.46
	Female	73	3.28	5.70	4.38 ± 0.44
	Total	124	3.28	6.05	4.48±0.47
Left kidney volume (Cm^3)	Male	51	85.45	199.20	125.33±26.60
	Female	73	55.62	186.27	107.94±27.68
	Total	124	55.62	199.20	115.09±28.46

Left kidney length (cm)	Male	51	8.48	12.44	10.27±0.94
	Female	73	7.47	12.54	10.03±1.10
	Total	124	7.47	12.54	10.13±1.04
Left kidney width (cm)	Male	51	4.02	6.23	5.05 ± 0.56
	Female	73	3.56	6.23	4.69± 0.56
	Total	124	3.56	6.23	4.84±0.58
Left kidney depth (cm)	Male	51	3.84	5.87	4.61 ± 0.45
	Female	73	3.22	5.37	4.31 ± 0.47
	Total	124	3.22	5.87	4.43±0.49

5.4.2 Correlation of kidneys volume and unidimensional size with demographic data

The volume of both kidneys was significantly correlated with weight, height, BMI, and BSA.A statistically significant negative correlation was seen with left Kidney volume and age. A negative correlation was seen with right Kidney volume and age, but, it was not statistically significant (p=0.057).The right kidney length, the left kidney length and left kidney width were showed a significant negative correlation with the age of the patient. The weight, height, BMI, and BSA significant positive correlation with the right kidney length and left kidney width

Table 9: Showing right and left kidney volume as well as unidimensional size measurements correlation with demographics data.

		Age	weight	height	BMI	BSA
Right Kidney volume (V)	Pearson Correlation	-0.171	0.463**	0.236**	0.417**	0.511**
	P-value	0.057	<0.001	0.008	<0.001	<0.001
Right kidney length	Pearson Correlation	-0.286**	0.372**	0.317**	0.194*	0.407**
	P-value	0.001	<0.001	<0.001	0.031	<0.001
Right kidney width	Pearson Correlation	-0.120	0.301**	0.360**	0.105	0.352**
	P-value	0.185	0.001	<0.001	0.247	<0.001
Right kidney depth	Pearson Correlation	-0.038	0.450**	0.307**	0.295**	0.475**
	P-value	0.671	<0.001	0.001	0.001	<0.001

Left Kidney volume (V)	Pearson Correlation	-0.193*	0.397**	0.208*	0.342**	0.435**
	P-value	0.032	<0.001	0.020	<0.001	<0.001
Left kidney length	Pearson Correlation	-0.381**	0.206*	0.270**	0.058	0.245**
	P-value	0.001	0.022	0.002	0.522	0.006
Left kidney width	Pearson Correlation	-0.186*	0.288**	0.252**	0.145	0.318**
	P –value	0.038	0.001	0.005	0.108	<0.001
Left kidney depth	Pearson Correlation	0.125	0.424**	0.260**	0.288**	0.445**
	P-value	0.168	<0.001	0.004	0.001	<0.001

5.4.3 Correlation between kidney volumes andone-dimensional measurements

The Right kidney volume was highly correlated positively with the maximum longitudinal length of the kidney determined on the coronal slice parallel to the long axis of the kidney ($r=0.835$, $p<0.001$) andmaximum width of the kidney on coronal image perpendicular to the length ($r= 0.775$, $p < 0.001$). The Left kidney volume was highly correlated reciprocally with the Kidney width on the coronal image ($r= 0.750$, $p < 0.001$).

Table 10: Showing right and left kidney volume correlation with unidimensional sizes

Right kidney volume		Right kidney length	Right kidney width	Right kidney depth
	Pearson Correlation	0.835**	0.775**	0.704**
	P value	<0.001	<0.001	<0.001
	N	124	124	124
Left kidney volume		Left kidney length	Left kidney width	Left kidney depth
	Pearson Correlation	0.726**	0.750**	0.731**
	P value	<0.001	<0.001	<0.001
	N	124	124	124

6. Discussion

Our study showed, the mean volume of the liver, spleen, right kidney, and left kidney were 1089.33 cm3 ± 257.73 mc3, 195.82 cm3 ± 84.72 cm3, 106.62±28.88 cm3, and 115.02±28.51 cm3 respectively. The mean maximum CC length, MHP CC length, the MHP AP diameter, and the maximum transverse diameter of the liver were found to be 14.88 ±1.94, 10.21± 1.73, 14.99 ±1.85, and 15.71 ± 2.19 respectively. In this study, the mean maximum length, width, and thickness of the spleen were 9.53 ± 1.53, 9.10±1.42, and 4.18 ± 0.91 respectively. The mean maximum length, width, and depth of the kidney were 9.83±1.02, 4.66±0.56, & 4.48±0.47 and 13±1.04, 4.84±0.58, & 4.43±0.49 on the right and left side respectively.

6.1 Liver volume and unidimensional size

In this study, the meanlivervolume for total study participates of 117 was1089.33 cm3 ± 257.73 mc3 with a range of 452.47-1750.92.This was lower than a study that reported hepatic volumes by Govil S, et al in 238 participants in India (mean 1186 cm3, range; 639.3-2359.4 cm3) (11). In other studies obtained by Verma .et.al (5) and Jasper A(1) also showed much higher mean liver volume with a value of 1106 cm3(range; 533-2417 cm3) and 1281±219.22 cm3 respectively. Both studies used volumetric software. This difference in the volume measurements might be explained by the difference in the body habitus of the study population as the volume of the liver was highly correlated with the BSA, weight, and BMI of the individuals which were shown in our study as well as the above-mentioned studies.

The mean liver volume of this study was also much less than the values obtained by Henderson JM et al., who obtained a mean liver volume of 1493 cm3 in 11 patients (12)and 1560 cm3 by Geraghty EM et al., in 149 patients (2). In both of those studies, volumetric software wasused to measure liver volumes which weredifferent from the technique used in our study. The difference in the measurements we obtained might be because both these studies were performed on a Western population and different measurement technique was used. The other study was conducted by Muggli D et.al(7)on 119 participants,which was used our technique of volume calculation by two radiologist separate measurements the liver volume found to be 1610 +/- 397 cm3 with a range of 786-2901 and 1640+/- 414 cm3 with a range of 795-2882.This is much higher than our study might be explained by the difference in the distribution of the demographic parameters. The liver volume of this study also was much less than the value obtained by Fatah et.al. (6)Using the same calculation method in 100 patients in our neighboring country Sudan which was 1802.38±10.31ml which explained by they included patients that had liver pathology which might increase the volume. Moreover, a study was done by SARATHI A, et.al (13) on 100 patients in eastern India by ultrasound volume measurement the mean value of liver volume was 1068.07 +/- 155.173 with limitation ultrasound being operator dependent, the liver volume appears near similar to our findings.

In this study, the mean maximum CC length, MHP CC length, the MHP AP diameter, and the maximum transverse diameter of the liver were found to be 14.88 ±1.94, 10.21± 1.73, 14.99 ±1.85, and 15.71 ± 2.19 respectively. The maximum CC length, the AP diameter, and the transverse diameter were lower than the study obtained by Muggli D et.al(7)which was 16.57+/-2.22, 16.46+/-2.26 and 18.95+/-2.27 respectively, and also lower than the study obtained by Fatah et.al (6). The difference in the size of the liver would be explained by the difference in the demographic status of the study population and the later study was also included patients which had liver pathology that might increase the size of the liver.

In our study, the liver volume and maximum AP diameter showed a significant positive correlation with the participant's weight, BMI, height, and BSA. This increase in the liver volume with an increase in BSA has been demonstrated earlier by Vauthey JN et al. and Sharma, D (2009) (14, 15)Kratzer et al.(16)sonographic survey in southern Germany consisted of 2,080 subjects (983 male, and 1,097 female); BMI and body height found to be the most important influencing factors of liver diameter when measured at the midclavicular line. They concluded that 16 cm or more in the right MCL be considered in cases of an enlarged liver. BMI and height must also be considered with care in a borderline case.

A negative correlation was seen between liver volumes and the age of the participant as seen in other studies done by Wynne HA et al., and Urata K et al (17, 18), but a study conducted by Sharma, D.(19) there was no significant correlation between liver volume and age. Some other studies even showed a positive correlation between age and liver volume. (Siddiqui TR, 2014)(20). The mean volume of the liver was slightly higher in the female with a value of 22.29 cm3 which was not significant like in other studies done by Jasper A., Kwo PY., andFraghaly S(1, 13, 21). But, there was a significant difference seen in a study done by Geraghty EM et al.,(2)(2)who found a 299 cm3 higher in males than females. The main explanation for our finding was more number of female participants.

6.2. Spleen volume and unidimensionalsize

In this study, the mean volume of the spleen in 147 total study participants was 195.82 cm3 ± 84.72 cm3 (211.83 cm3 ± 85.75 cm 3 and 186.25 ± 83.10 cm3 in males and females respectively) similar finding was obtained by V. Caglar et al. (22)Study done in turkey of 212 participants was 198 ± 88 cm3 (210 ± 90 cm3 and 184 ± 84 cm3 in males and females respectively). In another study done by jasper A. (1)in 100 participants, the mean splenic volume was 194.64±78.09 cm3 which was found to be the same value as our study. AdilAsghar et al.(23)measured splenic volume using volumetric software in the north Indian adult population was lower than our study and found to be 161.57 ± 90.2 cm3 (192 ± 54.91 cm3 in males, 118.39 ± 47.7 cm3 in females respectively). They found a significant difference in the two genders (11.8% higher in males than females, this difference is also seen in our study. Chhetri PK and Poudel S (24)volume assessment on CT in Nepalese population with summation method, the mean splenic volume was 130.16 ± 29.8 cm3, ranging from 49.5 to 201.4 cm3 which was lower than our study likely due to variation in the method of study and demographics data

Ahmed F. Musa et al. (8)conducted splenic volume measurement was done in 111 participants in Sudan kratom using the ellipsoid formula likely our study. The mean splenic volume of the participants was 165.5 ± 23 cm3(182.4 ± 25.8 cm3 and 148.5± 37.9 cm3 in males and females respectively). YaredTekle et al (25) conducted spleen size measurement on ultrasound at the University of Gondar hospital, northwest Ethiopia in 380 adults (180 males, 200 females), the mean splenic volume with 92.0±38.4 cm3 and another study done by Solomon demise et al(26)on 708 individuals in southern Ethiopia, Arba Minch town sonographic measurements the splenic volume was found to be 109.33 ± 61.68 which both of them were significantly lowerthan our measurement which could be explained by the sample size and operator dependent of the ultrasound.

The mean maximum lengthof the spleen was 9.53 ± 1.53 cm with a range of 6.01- 13.17 cm which was similar to another study done by V.caglar et al(22)the mean splenic lengthfor the total study population of 212 patients was 9.96 ± 2.1 cm. There were also similar values obtained by jasper A. (1)with the mean length of the spleen being 9.3 ±1.6 with a range of 4-13.5 cm. MulticentricSonographic evaluation of normal liver, spleen and renalParameters in adult population done by Khan, S., et.al in Pakistan A total of 2,212 participants was enrolled in the study The mean spleen lengthof the participants was 9.81 ±1.73 cm (27)

Another study was done on 380 patients in the northwest; Ethiopia by YaredTekle et al (25)on ultrasound the mean was 9.95 cm ±1.24 which was similar to our study. Contrary, In a study done by Spielmann AL et al. (28), 129 college athletes, obtained a splenic length greater than 12 cm in 31.7% of the men (mean spleen length, 11.4±1.7 cm) and in 12.8% of the women (mean spleen length, 10.3±1.3 cm). The length of the spleen had a statistically significant positive correlation with height, weight, and BSA which a similar correlation was obtained by NeetuArora et al (29)on sonographic splenic length measurement. In contradiction, a study was done by jasper A.(1)showed no association between splenic length with height & weight of participants.

In this study, there was a statistically significant positive correlation between spleen volume and weight, height, and BSA, similarly Chow Ku, et al demonstrated a significant positive correlation of the mean splenic volume with body height and weight (30). Moreover, study done by Harris et al (31)in 230 patients, the splenic volume (S) correlated with age (A) ($r = -0.33$, $p < 0.0001$), body weight (W) ($r = 0.35$, $p < 0.0001$), body mass index ($r = 0.24$, $p < 0.0001$) and body surface area (BSA) ($r = 0.31$, $p < 0.0001$).In contradiction to those studies, P.Prassopoulos. et al (32)found that the volume of the normal spleen did not correlate with an individual's age, height, weight, and BMI. Another study was done by Demise et al (26) in southern Ethiopia also demonstrated a significant positive correlation between the splenic volume with body height, weight, and BSA. YaredTekle et al also demonstrated a positive correlation between splenic volume and BMI(33)

Among the unidimensional indexes, the maximum spleen thickness on axial images showed the best correlation with splenic volumes (r=0.803), a similar finding was obtained by V. Caglar et al (22)with a strong association between splenic volume and thickness (r= 0.752). But, many other studies showedthe best correlation of splenic volume with length jasper A, Bezerra AS et al, and Chhetri PK&PoudelS(1, 24, 34)

6.3 kidneys volume and unidimensional size

In this study, the mean volume for the right kidney and left kidney in 124 of the study population were 106.62±28.88 cm3 (116.64 ± 29.02 cm3 in males & 99.62± 26.82 cm3in females) and 115.02±28.51 cm3 (125.34± 26.60 in male & 107.94 ± 27.68 in females) respectively.This was higher than a study done by Tallar SS. et al in 70 Indian individuals,using ellipsoid formula obtained the mean renal volume for the right kidney and left kidney was 94.18±23.68 cm3 and 98.07±24.92 cm3 respectively(9).Another large scales ultrasonographic volume measurement study done by Raza M et al.(35)in4,035 adult subjects in Pakistan, obtained renal volume of 99.8±37.2 cm3 & 124.4±41.3 cm3 on the right and left respectively with the left kidney is significantly larger than the right kidney which was similar to our study. Many other studies from different parties of the world showed much larger mean kidneys volume. Forinstance, in a study done by Cheong B et al.(36)intexas united States, the mean kidney volume estimated was 166±29 ml (male) & 130±30 ml (female) on the right side and 168±28 ml (male) & 131±33 ml (female) on the left side. Another study was done by Shin HS. et al (10)on113 young Korean, the mean kidney volume was 205.15 cm2 (right 203.26 ± 38.60 and left 207.32 ± 37.5) which was much higher than our study. The left kidney was significantly ($p < 0.05$) larger than the right kidney, a similar finding was obtained in this study too. Breau RH et al(37)also obtained mean kidney volume of 173 cm and 186 cm3 by ellipsoid formula and volumetric software respectively. The explanation for this variation in the renal size may include, ellipsoid formula(36, 38)underestimating the renal size and also due to the variation of the demographic profile of the study population. Another study was done in Nigeria on 114 voluntary adults on sonograph,the renal volume was 109.6 ± 29.3 on the right and 119.7 ± 32.8 on the left which was similar to our study(38). Another ultrasonographic volume measurementswere done by Desta d.et al(39)in Southwest Ethiopia in 175 diabetic adult patients, the mean volume of the right and left kidneys were 98.5 (± 23.2) and 105.4 (± 23.6) cm3, respectively which slightly lower than this study.

In our study, the kidney volume was significantly higher in males which also showed in previous different studies (10, 35, 36, 40). In contrary to most of the past researches, Rasmussen SN et al. did not notice any remarkable difference in renal volumes with gender (41)

The volume, length, width, and depth of both kidneys were significantly correlated with weight, height, BMI, and BSA. Many previous studies showed a significant correlation between renal size with height, weight, BMI, and BSA (35, 39, 42, 43).

Age is another very important parameter that usually affects the size of abdominal organsincluding the kidney. With regards to kidney size, aging leads to progressive renal size decrement, and our study also showed a significant negative correlation with renal size which is consistent with many other previous studies(35, 39, 43, 44). Prospective analysis of data from 1222 autopsies in the Legal Medicine Organization of Iran showed that kidney weights declined with age (45)and Buchholz NP et al.(46), reported that all renal dimensions increased with age till the 3rd decade, remained more or less stable through the middle age, then declined beyond the 6th decade.

In this study, the unidimensional measurements of the kidney including mean maximum length, width, and depth of the kidneywere 9.83±1.02, 4.66±0.56, and 4.48±0.47 and 10.13±1.04, 4.84±0.58, and 4.43±0.49 on right and left kidney respectively. There were similar measurements found in the previous studies, from the various continents.To mention some of them, Werner S Harmseand MB ChB(47) measured renal length on the coronal oblique image in 514 patients, the mean value was 10.8± 0.9 cm. Jabbari et al. (48) report the ultrasonographic mean renal length of 10.5 cm and 10.6 cm for the right and left kidneys of 103 adult Iranians. Similar findings are reported from Nepal, Southeast Asia (35) with a mean renal length of 9.5 cm. Reports from India (49, 50),Islamabad (43),and Nigeria (38)also show a similar pattern. Another study inJimmaUniversity, southwest Ethiopia of 175 diabetic patients sonographic mean value ofrenal length, width, and thickness was 10.3 cm, 5.2 cm& 3.5 cm and 10.4 cm, 5.2 cm, and3.5 cm on the right and left side respectively (39).

7. Conclusion

The mean volume of the liver, spleen, right kidney, and left kidney were 1089.33 cm3 ± 257.73 mc3, 195.82 cm3 ± 84.72 cm3, 106.62±28.88 cm3, and 115.02±28.51 cm3 respectively. The liver volume was lower than in different previous studies. The volume of the liver, the right kidney, and the left kidney were positively correlated with the height, weight, BMI, and BSA of patients. Splenic volume was also positively correlated with the weight, height, and BSA of the participants. The age of the patients was significantly negatively correlated with the liver and left kidney volume. Those correlations are indicating that whenever interpreting the size of the liver, spleen, and kidney the demographic parameters shouldbe considered. The mean maximum CC length, MHP CC length, the MHP AP diameter, and the maximum transverse diameter of the liver were found to be 14.88 ±1.94, 10.21± 1.73, 14.99 ±1.85, and 15.71 ± 2.19 respectively. The mean maximum length, width, and thickness of the spleen were 9.53 ± 1.53, 9.10±1.42, and 4.18 ± 0.91 respectively. The mean maximum length, width, and depth of the kidneywere 9.83±1.02, 4.66±0.56, &4.48±0.47 and13±1.04, 4.84±0.58, &4.43±0.49 on the right and left side respectively. Among the unidimensional indexes, liver volume showed the best correlation with the maximum craniocaudal length ($r=0.636$) and splenic volume showed the best correlation with the maximum thickness ($r=0.803$). The Right kidney volume was best correlated with the maximum longitudinal($r=0.835$, $p<0.001$) and the left kidney was best correlated with width.

8. Recommendations

This study was single institutional-based may be used as an entry point to do multicentric large-scale studies and to establish a normal range of liver, spleen, and kidney size measurements. The correlation of the linear measurements with organs volume needs further study to volumetric software to establish the best single linear measurements for CT scan.

9. Limitations of the study

The main limitation of this study, all volume measurements of the liver, kidney, and spleen were exported from the linear measurements which might not show the actual volumes using volumetric software. The measurements were also taken by a single person and interpersonal variation should be considered. The exclusion was based on available data and imaging findings, so some of them might have a subclinical disease that could affect the size of the visceral organs.

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ANNEX-1: English Version Questionnaire

Questionnaire ID**: -----------**

1. demographic data
   1.1. Age ---------
   1.2. Sex-------- possible answer 1. Male 2. Female
   1.3. Weight ------------
   1.4. Height ---------
   1.5. Body mass index(BMI)----------
   1.6. Body surface area(BSA)----------

2. Liver size measurement parameters

No.	Symbol	Description	Measurement in cm/cm3
2.1	L1	Maximum cranio-caudal(max CC) length of liver at any point on coronal image	
2.2	L2	Midhepatic point craniocaudal(MHP CC) length	
2.3	L3	Maximum anteroposterior diameter of the liver at MHP(MHP AP)	
2.4	L4	Maximum transverse diameter through right and left lobe.	
2.5	LV	Liver volume = Max.CC length* max.AP diameter*max. transferse diameter *0.31	

3. Spleen size measurements parameters

No.	Symbol	Description	Measurement in cm/cm3
3.1	SL	Maximum length of spleen on coronal image.	
3.2	SW	Maximum width of the spleen on axial image.	
3.3	ST	Maximum thickness of the spleen perpendicular to maximum width on axial image.	
3.4	SV	Splenic volume by ellipsolid equitation(0.524*max.length*max.width *max.thickness	

4. Renal measurement parameter

No.	Symbol	Description	Measurement in cm / cm3
4.1	KL	The maximum longitudinal length of the kidney determined on the coronal slice parallel to the long axis of kidney	RK=
			LK=
4.2	KW	Maximum width perpendicular to the renal length on the identical slice of CT where renal length was localized	RK=
			LK=
4.3	KD	Maximum depth of kidney right angle to the renal length in a thick sagittal slice of CT scan image	RK=
			LK =
4.4	KV	Kidney volume (V) =л/6(0.524) x L x W x D	RK=
			LK =