Sonographic Evaluation of Gallbladder Dimensions in Healthy Adults in Benin City, Nigeria

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ABSTRACT

Background: Several disease conditions can affect gallbladder (GB) size and wall thickness (WT). Imaging methods are superior to clinical evaluation in assessing GB dimensions. Ultrasonography is a relatively safe, inexpensive and reproducible imaging modality for assessing normal or diseased GB. There are few reports on normal GB dimensions in the Nigerian medical literature. This study therefore set out to contribute to data on GB dimensions among Nigerians. **Materials and Methods:** This was a prospective study. Three hundred and twenty-two healthy adult volunteers, consisting of 133 males and 189 females were assessed, by ultrasound, following over night fasting. GB length, width, height and WT were measured for each subject. GB-V was calculated by the ellipsoid formula. Data analysis included descriptive statistics and comparison of measurements with biometric parameters. Statistical significance between the variables was done with the Students *t*-test, with '*P*' value set at ≤0.05. **Results:** One hundred and thirty-three males (41.3%) and one hundred and eighty-nine females (58.7%) were studied. The mean age of subjects was 31.92±11.7 years. The mean values of the length (L), height (H), and width (W) of the GB were 6.16±1.09 cm; 2.75±0.58 cm; and 2.98±0.59 cm respectively. Mean GB-V was 27.2±12.8 cm^3 and WT 0.25±0.04 cm. Age and gender did not significantly influence GB measurements. **Conclusions:** A normal range of GB dimensions for the Benin City locality has been established. The study confirmed the non-dependence of GB measurements on age and gender.

Key words: Benin City; dimension; gallbladder; size; ultrasonography

Introduction

The gallbladder (GB) is a pear-shaped structure located on the visceral surface of the liver. It functions to store and concentrate bile for release into the duodenum during digestion.[1] Clinically a normal GB cannot be palpated, unless it is enlarged. GB size varies between fasting and postprandial states, and its wall thickness (WT) is influenced by the degree of distension.[2] Several disease conditions that affect the hepatobiliary system can cause alteration in GB-V and WT. Such conditions include choledocholithiasis, obstructive pancreatic lesions, among others.

Imaging methods available for assessing the GB include cholecystography, ultrasonography, computed axial tomography and magnetic resonance imaging.[2,3] However, ultrasonography (transabdominal) is the modality of choice because it is cheap, reproducible and does not utilize ionizing radiation. It provides information about GB-V and WT and has high specificity and sensitivity in identifying GB pathologies such as distension, contraction, sludge, stones and tumours.

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Sonographically, the GB is seen as a hollow organ, in the GB fossa between the right and quadrate lobes of the liver. In parasaggital scans, it lies between the liver and the kidney. It appears as a hollow viscus, with smooth margins and contains anechoic fluid that gives distal acoustic enhancement. The GB wall, consisting of the mucous, muscular and serous layers appears on ultrasound scan as a hyperechoic inner and outer layers and a less echogenic middle layer, especially when contracted.[3]

Several sonographic methods have been used to assess GB-V, including two-dimensional ultrasonography, using the sum of cylinders and the ellipsoid method, as well as three-dimensional ultrasonography.

There are few documented reports on sonographic assessment of GB dimensions, including WT in the Nigerian environment.[4,5] However no such data are available from the Benin-City and environs. This study was carried out to provide such information.

Materials and Methods

This was a prospective ultrasonic study of GB dimensions in 322 (Three hundred and twenty-two) apparently healthy adult volunteers, consisting of 133 males and 189 females. Subjects were mainly staff and students of the University of Benin, and the University of Benin Teaching Hospital (UBTH).

It was carried out at the radiology department of the UBTH between January and September 2009. Approval for the study was obtained from the ethical committee of the UBTH. Exclusion criteria included age less than 18 years, diabetes, recent history of jaundice, haemoglobinopathies, and previous hepatobiliary surgery. Subjects on concurrent medications like non-steroidal anti-inflammatory drugs, atropine and prostigmine, and those with incidental findings of GB pathology during scanning, were also excluded. Informed consent was obtained from each subject. Biometric parameters including age, sex, height and weight were recorded.

Following overnight fasting,[6] recruited subjects were scanned using a digital real-time ultrasound system-model CTS-7700 (SIUI Inc. China), with a 3.5 MHz convex transducer. Each subject was asked to lie supine with the hands placed under the head to widen the intercostal spaces. The GB was scanned both longitudinally and transversely. Measurements (in cm) in the maximum longitudinal and transverse axes of the GB were taken thrice and the average for each recorded. The length (L) and WT were taken in the longitudinal and axial planes, while the width (W) and height (H) were taken in the transverse section. The WT was measured in each subject at the midpoint of the GB wall adjacent to the liver. GB-V was calculated by the ellipsoid formula. The data obtained was entered into Microsoft Excel database and statistically analyzed using Statistical Package for Social Science (SPSS) for windows (SPSS Inc., USA) Version 15.0. The GB dimensions and WT were subjected to descriptive statistics using measures of central tendency and dispersion and also was compared with age, sex, height, body mass index (BMI) and body surface area (BSA). Data comparison (statistical test of significant between the various variables) was done with Students *t*-test. At 95% interval, two tailed "*P*" Values less than or equal to 0.05 were considered as statistically significant.

Results

Three hundred and twenty-two healthy subjects consisting of 133 males (41.3%) and 189 females (58.7%) were studied. The age range of the subjects was 18-80 years. The modal age group was 21-30 years (77 males and 84 females), with the median age 31.92±11.7 years. The range of values for other demographic parameters of the study subjects is summarized in Table 1.

The mean values of the length (L), height (H) and width (H) of the GB for the study population were 6.16±1.09 cm (range 1.14-9.57 cm); 2.75 cm±0.58 cm (range 1.42-4.92 cm) and 2.98±0.59 cm (range 1.5-4.87 cm) respectively. The mean GB-V and WT was 27.2±12.8 cm^3; (range 6.96-108.1 cm^3) and 0.25±0.04 cm (range 0.16-0.42 cm) respectively.

Mean GB length (L) for males was 6.30±0.92 cm, height (H): 2.79±0.56 cm; width (W) was 3.02±0.56 cm; volume (V) was 28.39±12.3 cm^3; and WT; 0.25±0.04 cm. For females, the corresponding mean GB length (L) was 6.07±1.18 cm, height: 2.72±0.59 cm, width (W): 2.95±0.59 cm; volume (V) 26.37±13.0 cm; and WT: 0.25±0.04 cm.

Comparison between the mean GB dimensions and WT for males and females (using unpaired *t* test) showed no statistically significant difference (*P*=0.069, 0.294, 0.244, 0.162 and 0.961) for GB length, height, width, volume and WT respectively [Table 2].

Analysis of variance (ANOVA) showed no statistically significant difference in GB dimensions among the different age groups (*P*=0.087, 0.823, 0.850, 0.642 and 0.326), for length, height, width, volume and WT respectively; Table 3. The age group 51-60 years had the highest mean GB-V (30.82±11.74 cm^3), while age group 61-70 years had the highest GB WT (0.28±0.06 cm).

In this study, GB length, height, width, volume and WT

Table 1: Mean values of age and biometric parameters of study subjects

Parameter	All subjects *n*=322	Males *n*=133	Females *n*=189
Age (yrs)	31.92±11.71	31.44±10.91	32.26±12.26
Age range	(16-80 yrs)	(16-75 yrs)	(17-18 yrs)
Height (m)	1.67±0.09	1.73±0.09	1.63±0.08
Height range (m)	(1.18-1.98m)	(1.39-1.98)	(1.18-1.80)
Weight (kg)	65.42±11.06	68.87±10.44	63.01±10.87
Weight range	(35.0-113.0 kg)	(35.0-113.0 kg)	(41.0-103.0 yrs)
BMI (kg/m²)	23.58±4.17	23.11±3.14	23.92±4.74
BMI range	(14.96-43.67)	(14.96-37.32)	(16.71-43.67)
BSA (m²)	1.73±0.17	1.81±0.16	1.67±0.15
(BSA range)	(1.16-2.26)	(1.16-2.26)	(1.22-2.04)

BSA – Body surface area; BMI – Body mass index

Table 2: Relationship between gall bladder dimensions and gender

	Female	Males	*P* value
Length (cm)	6.07±18	6.30±0.92	0.069
Height (cm)	2.72±0.59	2.79±0.56	0.294
Width (cm)	2.95±0.59	3.02±0.56	0.244
Volume (cm^3)	26.37±13.04	28.39±12.33	0.162
Wall thickness (cm)	0.25±0.04	0.25±0.04	0.961

P≤0.05 is significant

showed no statistically significant difference with the heights of study subjects (P=0.234, 0.054, 0.051, 0.222 and 0.059 respectively). However, there was statistically significant relationship between GB height, width, and volume with subject body weights; P=0.013, 0.014, 0.010 respectively [Table 4]. Subjects with weight range 85-94 kg had the highest mean GB-V of 32.43±15.95 cm^3. GB WT and length had no statistically significant relationship to body weight; (P=0.141, 0.564). BMI had no statistically significant relationship to GB length, height, width, and volume (P=0.331, 0.303, 0.737, 0.392) respectively.

BSA of subjects showed significant relationship with all GB dimensions (P=0.01), except for length and WT; (P=0.904 and 0.089) respectively.

Correlation and repression analysis showed significant correlation between the weight of subjects and GB height and width (P=0.013, r=0.122; P=0.014, r=0.125). There was strong correlation between weight and GB-V (P=0.010, r=0.148); Table 5.

There was no statistically significant relationship between the weights of subjects and GB length (P=0.0564, r=0.094), or WT.

The BMI showed no significant linear correlation with GB dimensions (P=0.066, 0.285, 0.175, 0.097, 0.051 and r=0.102, 0.059, 0.075, 0.092 and 0.108), that is, for GB length, height, width, volume and WT respectively.

Comparison of the BSA of subjects with GB dimensions showed significant relationship with height, width and volume of the GB (P=0.006, 0.007). There was no significant association of BSA with length and WT, (P=0.904; 0.089 respectively) [Table 6].

Simple linear regression also showed significant relationship

Table 3: Mean values of gallbladder dimensions for the age groups

	Below 20 yrs	21-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	61-70 yrs	71-80 yrs	*P* value
Length (cm)	5.99±1.05	6.13±0.96	6.23±1.07	5.95±1.61	6.70±1.12	6.98±0.78	5.72±0.86	0.087
Height (cm)	2.81±0.64	2.72±0.55	2.79±0.61	2.67±0.68	2.88±0.40	2.67±0.361	2.57±0.42	0.823
Width (cm)	2.97±0.57	3.00±0.58	2.97±0.62	2.93±0.62	2.95±0.51	2.97±0.30	2.55±0.53	0.850
Volume (cm^3)	26.59±11.14	27.12±13.11	28.09±12.96	24.65±13.83	30.83±11.74	29.42±7.94	20.61±12.77	0.642
Wall thickness (cm)	0.24±0.04	0.25±0.04	0.25±0.04	0.25±0.04	0.25±0.03	0.28±0.06	0.22±0.01	0.326

P≤0.05 is significant

Table 4: Comparison of height grouping against gall bladder dimension

	1.00-1.20 m	1.21-1.40 m	1.41-1.60 m	1.61-1.80 m	1.81-2.00 m	*P* value
Length (cm)	6.67±0.00	7.50±0.28	6.21±1.02	6.11±1.11	6.47±1.04	0.234
Height (cm)	2.82±0.00	2.41±0.56	2.58±0.50	2.80±0.59	2.64±0.65	0.054
Width (cm)	3.20±0.00	3.02±0.65	2.78±0.57	3.02±0.58	3.08±0.57	0.051
Volume (cm^3)	31.30±0.00	28.78±11.61	23.90±10.27	27.92±12.66	29.01±20.00	0.222
Wall thickness (cm)	0.34±0.00	0.24±0.04	0.24±0.04	0.25±0.04	0.25±0.04	0.059

P≤0.05 is significant

Table 5: Comparison of weight grouping against gall bladder dimension

	35-44.9 kg	45-54.9 kg	55-64.9 kg	65-74.9 kg	75-84.9 kg	85-94.9 kg	*P* value
Length (cm)	5.99±1.13	5.93±1.16	6.11±1.00	6.28±1.18	6.22±0.96	6.36±1.52	0.564
Height (cm)	2.63±0.42	2.49±0.49	2.80±0.57	2.71±0.55	2.90±0.65	2.90±0.80	0.013
Width (cm)	3.05±0.37	2.68±0.51	2.99±0.53	3.02±0.62	3.08±0.67	3.16±0.43	0.014
Volume (cm^3)	25.60±9.43	21.12±9.08	27.61±12.23	27.25±11.78	30.64±16.64	32.43±15.0	0.010
Wall thickness (cm)	0.24±0.06	0.25±0.04	0.25±0.04	0.24±0.04	0.25±0.04	0.28±0.04	0.141

P≤0.05 is significant

Table 6: Comparison of body surface area grouping against gall bladder dimension

	1.21-1.40	1.41-1.60	1.61-1.80	1.81-2.00	>2.01	*P* value
Length (cm)	6.17±1.09	6.08±1.05	6.17±1.19	6.16±0.86	6.39±1.32	0.904
Height (cm)	2.55±0.41	2.57±0.51	2.80±0.59	2.73±0.55	3.11±0.65	0.006
Width (cm)	2.94±0.35	2.76±0.51	3.03±0.58	2.98±0.60	3.27±0.61	0.007
Volume (cm^3)	24.35±7.75	23.07±9.74	28.25±13.16	26.79±11.25	36.09±21.76	0.003
Wall thickness (cm)	0.28±0.06	0.24±0.04	0.25±0.04	0.24±0.04	0.26±0.05	0.089

P≤0.05 is significant

between the weight of subjects and GB height and width (P=0.013, r=0.122) and GB-V (P=0.010, r=0.1477). However there was no statistically significant relationship between body weight and GB length and WT (P=0.564, 0.141, r=0.0942, 0.0581 respectively).

Scatter plot graphs were also done which showed the positive relationship between GB-V and subject weights and BSA; Figures 1 and 2. A linear repression equation was also formulated for each relationship, which can be used for quick prediction of the GB-V from the weight and BSA of the subject.

Both Pearson's correlation and simple linear regression showed significant relationship between subject's weight and BSA with GB-V, height and width. The strongest relationship was between GB-V and subject weight.

Figure 3 shows longitudinal and transverse sonograms of fasting GB, and how maximum length (L), width (W), and height (H) were measured.

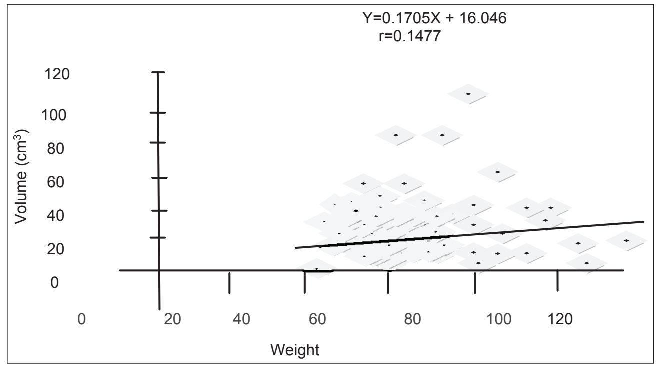

Figure 1: Scatter plot graph showing the linear regression of gallbladder-Volume with subject weight and the regression equation

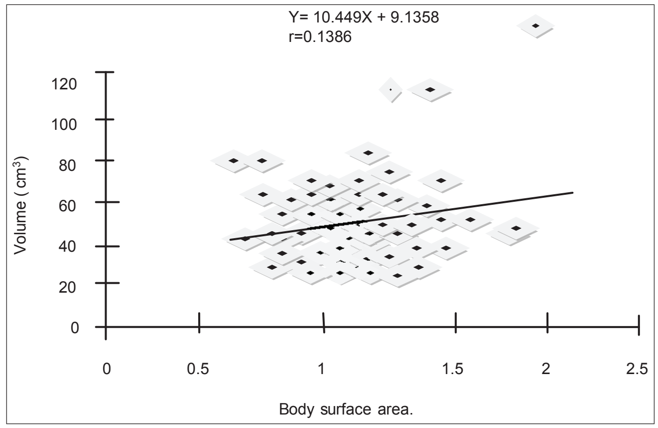

Figure 2: Scatter plot graph showing the linear regression of GB-Volume With BSA of subjects and the regression equation

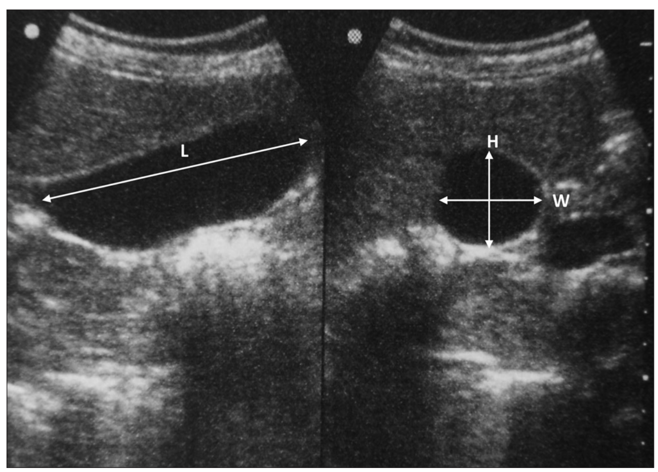

Figure 3: Longitudinal and transverse sonograms of the gallbladder showing measurement planes for length (L), width (W), and height (H)

Discussion

In this study, the mean length, height and width of the GB were obtained and used to calculate the GB-V, using the ellipsoid formula as proposed by Dodds *et al*.[7]

We found a mean GB-V of 27.2±12.8 cm^3; mean length of 6.18±1.15 cm; and mean WT of 0.25±0.04 cm. Ugwu[4] in Abakaliki found a mean GB-V of 29.29±13.75 cm^3. This may be suggestive of lack of significant variation in GB-V among Nigerians.

Studies on GB-V on normal, diabetic and pregnant subjects are available in the international literature.[8-13] Sari *et al*.,[10] Kishk *et al*.,[13] in separate studies in Turkey and Wisconsin documented similar mean GB-V of 28.1±12.3 cm and 28.0±12.0 cm respectively in normal subjects. The similarities between these studies and the current one would suggest lack of significant racial variation in GB-V.

Olokoba *et al*.,[5] in Ilorin, Nigeria studied the relationship between gallstone disease and GB WT and found mean GB thickness to be 2.1±1.2 mm; not significantly different from 0.25±0.4 mm found in the study. Various studies among Caucasians[1,3] have given values that suggest an average GB length of 7.5 cm, transverse and anteroposterior diameter of 3 cm, WT 3 mm and volume of 30-40 cm^3, again showing no significant differences in these values and those obtained in this study.

GB dimensions have been documented by some reports to vary with age, sex, weight, height, BMI and BSA.[8,10-13] In this study, the mean GB-V in males was 28.39±12.33 cm^3 and for females 26.37±13.04 cm^3 (P=0.162). Thus this study did not find any statistically significant difference in GB-V among genders. Nieves *et al*.,[9] in their study among Spaniards also found no influence of gender on GB dimensions. Ngige *et al*.,[14] in their study on children with sickle cell disease also did not report any influence of gender on GB dimensions.

There was no influence of age on GB dimensions in this study, contrasting with the finding of Caroli-Bose *et al*.,[8] in their work on the relationship between GB-V and demographic parameters where they documented GB-V to be positively correlated with age. Also a study on the sonographic measurement of normal GB sizes in Korean children by Yoo *et al.*,[15] and by Ngige *et al.*,[14] in Nigeria showed positive correlation between GB-V and age. It is important to note that these studies were done among children; therefore the reason for the positive correlation could be due to that fact that most organs tend to increase in size during the active growth phase.

Weight and BSA of the subjects in this study positively correlated independently with the width, height and volume of the GB. Other studies also reported weight of the subject to be positively correlated with GB-V. Yoo *et al.*,[15] and Sari *et al.*,[10] in GB studies among Asians found positive correlation between subject weight and GB-V.

This study did not show any relationship between BMI and GB length, width, height and volume. There was no statistically significant influence of weight on GB-V. Caroli-Bose[8] and co-workers made similar observations. A Nigerian study by Ugwu[4] however, did show a relationship between BMI and GB-V. Other studies have demonstrated greater fasting GB-V in obese subjects than in non-obese controls.[10] A possible explanation for this may be that BMI does not differentiate between body fat mass and muscle mass, and that BMI may not truly reflect body fat mass in this environment. In the same vein, using correlation and regression analysis, there was no positive correlation between GB WT and the BMI.

The BSA showed positive correlation with the width and volume of the GB in this study, a finding similar to that of Ugwu[4] in Abakaliki and several studies overseas.[10,15,16] We were able to establish that there is no significant difference in mean GB-V and WT in this environment from those of Caucasians. The pattern of correlation between GB-V and demographic parameters, however, tend to vary among different studies. This study established BSA and subject weight to positively and significantly correlate with the GB-V.

From the regression values of GB-V on weight, and BSA of the subjects, (as shown in Figures), a regression equation was derived for the determination of GB-V as follows:

$GB - V = (0.1705 \times \text{Weight}) + 16.046$; $r = 0.1477$. $GB - V = (10.449 \times BSA) + 9.1358$; $r = 0.1386$. These equations may be useful in clinically predicting the GB-V of healthy subjects.

Conclusions

This study has been able to establish a normal range of GB dimensions in asymptomatic adults in Benin-City. It also confirmed the independence of GB dimensions on race and gender.

A strongly positive correlation between subject weight and BSA with GB-V was found.

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