

Ultrasound evaluation of gallbladder dimensions in healthy adults

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Abstract

Background and objective: The gallbladder size, volume, and wall thickness can be affected by many disease processes. Therefore, there is a need to establish a baseline sonographic normogram of gallbladder dimensions and volume for early detection and follow-up of a diseased gallbladder. This study aimed to establish a baseline sonographic normogram for gallbladder volume and wall thickness in normal adults and its relationship with age, gender, and body mass index.

Methods: This prospective cross-sectional study was conducted on 400 normal adult subjects aged 18-73 years at the Radiology Department of Rizgary Teaching Hospital and Private Clinic in Erbil city, Kurdistan Region of Iraq. Gallbladder dimensions, including height, length, width, volume, and wall thickness, were measured by sonographic scanning of the subjects' gallbladder after an overnight fasting.

Results: Out of 400 subjects, 248 (62%) were male, and 152 (38%) were female. There was a slight difference between male and female gallbladder volume (29.87 ml for males and 26.5 ml for females) and wall thickness (2.53 mm for males and 2.46 mm for females), with the measurements slightly higher in males. A statistically significant variation was found between gender and age of participants with gallbladder height (ranging 2.4-3.06 cm), width (ranging 2.41-3.38 cm), volume (ranging 21.03-38.39 ml), and wall thickness (ranging 2.16-2.96 mm). A non significant correlation was found between the age and gender of participants with the length of the gallbladder (ranging 6.33-6.61 cm). A moderately significant correlation was found between gallbladder volume with height and weight of participants. A weak significant statistical relation was found between gallbladder volume and the body mass index of participants.

Conclusion: Normal gallbladder sonographic dimensions have been established in our locality to be used as a reference value for evaluating the healthy and diseased gallbladder. The mean volume for males was 29.87cm³, and for females was 26.57cm³. The mean wall thickness for males was 2.53mm and 2.46 mm for females. The mean height was 2.92cm for males and 2.76cm for females. The mean width was 2.93 cm for males and 2.78cm for females. The mean length was 6.54 cm for males and 6.46 cm for females.

Keywords: Ultrasound; Gallbladder; Dimensions; Kurdistan; Erbil.

Introduction

The gallbladder is a saccular pear-shaped structure with thin and regular walls, situated in an area devoid of visceral peritoneum called the gallbladder fossa between segments IV and V of the posterior right hepatic lobe. Parts of the gallbladder are fundus, body, infundibulum,

neck, and Hartman's pouch that connects the body with the neck. It has an important role in the storage, concentration, and periodic release of bile into the duodenum for the normal digestive process of fat. Normally bile flows from the gallbladder into the cystic duct, which joins the common hepatic duct to form the common

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bile duct that opens into the ampulla of Vater.^{1,2}

For evaluating gallbladder and biliary tree, various radiological imaging investigations have evolved from cholecystography to more modern imaging modalities like dynamic ultrasonography, dynamic cholescintigraphy, computed tomography, magnetic resonance imaging, and endoscopic retrograde cholangiopancreatography.

Ultrasonography is the first imaging modality of choice for assessing the gallbladder since it is cheap, available, reproducible, and has no radiation hazards.³ Determination of gallbladder size is important since gallbladder volume can be increased both in a physiological state like pregnancy and pathological conditions like cholelithiasis, primary sclerosing cholangitis, primary biliary cirrhosis, and non-insulin-dependent diabetes mellitus.⁴ Thickening of the gallbladder wall can be caused by several conditions like cholecystitis, pancreatitis, hepatitis, and pyelonephritis.⁵

Routinely transabdominal sonography is performed for evaluation of gallbladder using a systematic approach to obtain longitudinal and cross-sectional images of the organ assessing its shape, dimensions, wall thickness, regularity and texture pattern of the wall and contents.⁶ Sonographically, the gallbladder appears as a hollow viscus containing echo free fluid that gives posterior acoustic enhancement,^{1,2} with a thin, smooth wall comprising of three layers; mucosa which is the inner most linear echogenic layer, muscular layer which is thin and slightly hypoechoic, the outer most layer is the serosa which is linear, regular and echogenic. The upper limit of normal gallbladder wall thickness is 3 mm.^{7,8}

A total of 6-8 hours of fasting is recommended because in patients under inappropriate fasting, the parietal thickness may exceed such a limit because of gallbladder smooth muscle contraction.² The method accuracy can be enhanced by

using harmonic imaging, which increases lateral resolution, signal -noise and contrast-noise ratio.¹

This study aimed to establish a baseline sonographic normogram for gallbladder volume and wall thickness in normal adults and its relationship with age, gender, and BMI.

Methods

This was a randomized cross-sectional prospective ultrasound study of gallbladder dimensions involving 400 adults with ages ranging 18-73 years, comprising 248 males and 152 females, conducted over 6 months between October 2020 and March 2021 at the Ultrasound Department of Rizgary Teaching Hospital and private ultrasound clinic in Erbil, Kurdistan Region of Iraq. Exclusion criteria were age less than 18 years, a recent history of jaundice, pregnancy, diabetes, sickle cell disease, previous hepatobiliary surgery, gallbladder disease observed during ultrasound scanning, and patients using anticholinergic drugs. Ethical approval was obtained from the Ethical Committee of the College of Medicine, Hawler Medical University, before the commencement of the study. Written informed consent was obtained from each subject.

Ultrasound scanning was done for the subjects following 6-8 hours of fasting to ensure adequate gallbladder distension and reduce the amount of gastric and intestinal gas.⁹

Each subject was asked to lie in supine and right anterior oblique position with hands raised and placed under the head to widen the intercostal spaces. An adequate amount of coupling gel was applied over the gallbladder region at the right hypochondrium using a 3.5MHz curvilinear probe.

The height (in meters) and weight (in kilograms) of the subjects were measured, the body mass index (BMI) was obtained using a formula of $\text{weight}/\text{height}^2$ (kg/m^2) gallbladder measurements (in centimeter) were taken with the probe placed over

the right hypochondrial region in the midclavicular line and angled cranially both in longitudinal and transverse planes. After obtaining the maximum longitudinal outline of gallbladder, the length and wall thickness were measured in the longitudinal plane in arrested respiration. Then, the probe was rotated through 90 degrees to obtain the maximum transverse plane. Then, the width (W) and height (H) were measured. The gallbladder volume (cm)³ was obtained using the prolate ellipsoid formula (L X H X W X 0.523)

Statistical analysis

The statistical package for the social sciences (SPSS version 25) was used for data entry and analysis. Two approaches were used; first descriptive statistics to determine percentages and frequencies. In the second approach (analytic statistic),

the Pearson correlation test was used to determine the relationship between continuous numerical data illustrated by a scatter diagram. Two samples independent t-test was used to calculate the mean difference between two independent variables. Finally, the ANOVA test was used to differentiate between more than two means. A *P* value of ≤0.05 was regarded as statistically significant.

Results

Out of 400 subjects, 248 (62%) were males, and 152 (38%) were females, with a mean age was 38.85±13.48, ranging from 18-73 years and one third (32%) of participants were in their third decade of life (30-39 years). The mean BMI was 25.99 ±2.67, and more than half of them (57.8%) were overweight (Table 1).

Table 1 Certain socio-demographic characteristics of the study participants

Variables	No.	%
Gender		
Male	248	62.00
Female	152	38.00
BMI		
Normal weight	140	35.00
Over weight	231	57.75
Obese	29	7.25
Age group		
<20	20	5.00
20-29	86	21.50
30-39	128	32.00
40-49	100	25.00
50-59	25	6.25
60-69	31	7.75
≥70	10	2.50
Total	400	100

Table 2 shows the mean \pm SD of Gallbladder wall thickness in mm, height, width, and length in cm.

There was a statistically significant association between gender and age groups with gallbladder wall thickness,

height, width, and gallbladder volume.

The means were highest among males than females. The relationship between gender and age groups with the length of the gallbladder was statistically nonsignificant (Table 3).

Table 2 Mean \pm SD of gallbladder wall thickness, height, width, and length

	Gallbladder wall thickness in mm	Gallbladder height in cm	Gallbladder width in cm	Gallbladder length in cm
Mean	2.50	2.85	2.87	6.51
SD	0.27	0.42	0.42	0.61
Minimum	2.0	1.8	1.7	4.4
Maximum	3.0	3.6	3.6	8.2

Table 3 Association between gender and age groups with gallbladder measurements

Variables	Mean \pm SD				
	Gallbladder wall thickness in mm	Gallbladder height in cm	Gallbladder width in cm	Gallbladder length in cm	Gallbladder volume in cm ³
Gender					
Male (n=248)	2.53 \pm 0.26	2.92 \pm 0.42	2.93 \pm .41	6.54 \pm 0.61	29.87 \pm 8.86
Female (n=152)	2.46 \pm 0.28	2.76 \pm 0.42	2.78 \pm .42	6.46 \pm 0.60	26.57 \pm 9.1
P value	0.011	<0.001	<0.001	0.193	<0.001
Age group					
<20 (n=20)	2.16 \pm 0.21	2.5 \pm 0.67	2.41 \pm .6604	6.33 \pm 0.56	21.03 \pm 13.1
20-29 (n=86)	2.26 \pm 0.21	2.4 \pm 0.44	2.67 \pm 0.45	6.53 \pm 0.7	25.22 \pm 9.72
30-39 (n=128)	2.44 \pm 0.2	2.66 \pm 0.37	2.93 \pm 0.35	6.5 \pm 0.51	29.79 \pm 7.59
40-49 (n=100)	2.64 \pm 0.13	2.94 \pm 0.33	2.9 \pm 0.31	6.55 \pm 0.62	28.94 \pm 7.41
50-59 (n=25)	2.77 \pm 0.04	2.87 \pm 0.32	2.98 \pm 0.33	6.43 \pm 0.71	29.96 \pm 8.36
60-69 (n=31)	2.88 \pm 0.07	2.94 \pm 0.39	3.09 \pm 0.37	6.45 \pm 0.66	32.81 \pm 10.12
\geq 70 (n=10)	2.96 \pm 0.05	3.06 \pm 0.21	3.38 \pm 0.23	6.61 \pm 0.55	38.39 \pm 6.07
P value	<0.001	<0.001	<0.001	0.780	<0.001

There was a statistically significant moderate positive correlation between gallbladder volume with height and weight

of the participants, ($r=0.521$, $r=0.517$) respectively, ($P < 0.001$ for both), as shown in Figures 1 and 2.

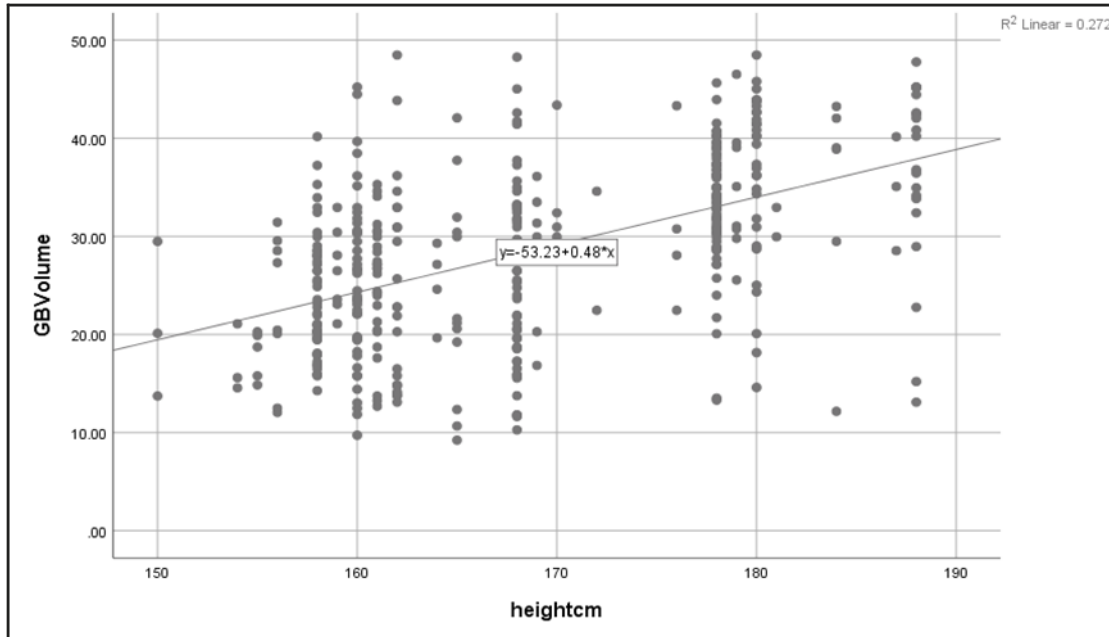


Figure 1 A scatter diagram showing linear relation between gallbladder volume and height of participants

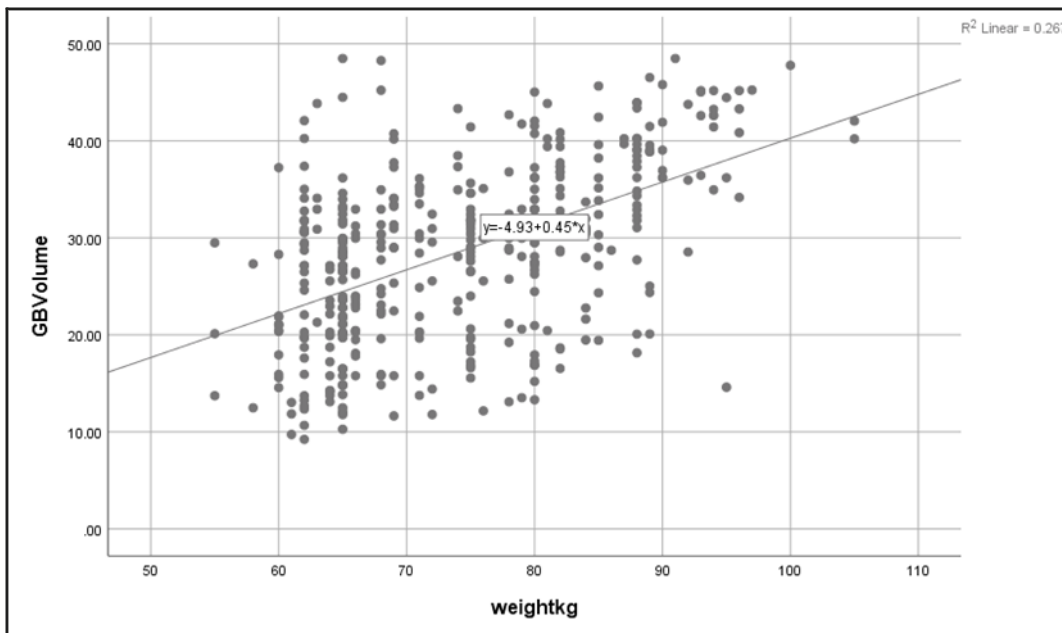


Figure 2 A scatter diagram showing linear relation between gallbladder volume and weight of participants

There was a statistically significant weak positive correlation between gallbladder volume with the BMI and the age of

the participants ($r=0.107$, $P = 0.032$, $r=0.327$, $P < 0.001$, respectively), as shown in Figures 3 and 4.

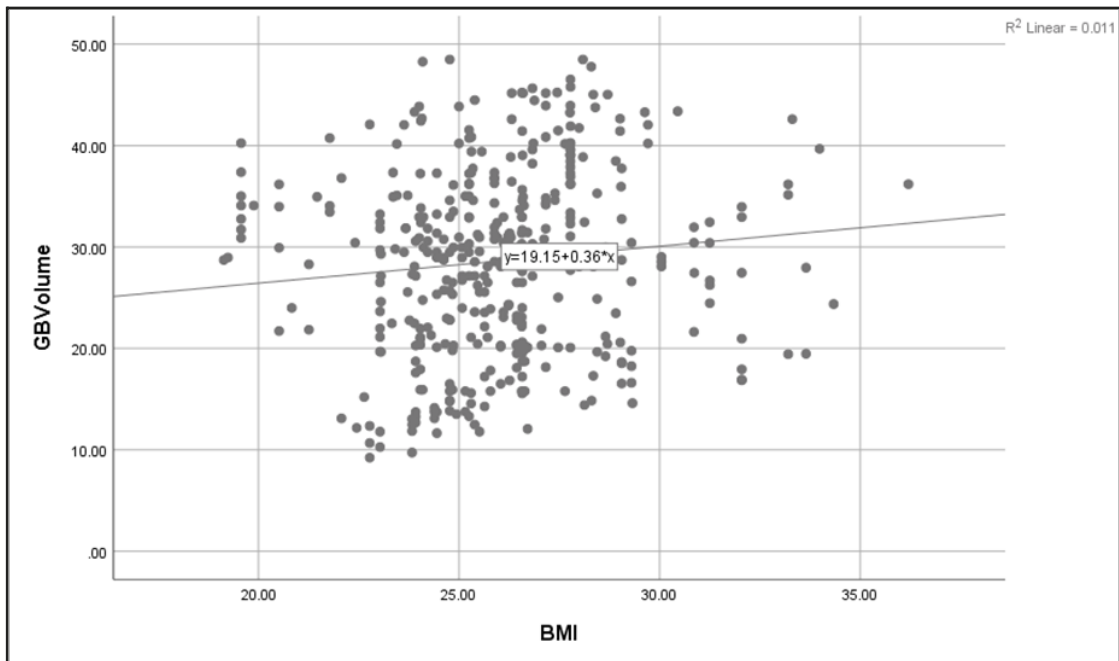


Figure 3 A scatter diagram showing linear relation between gallbladder volume and BMI of participants

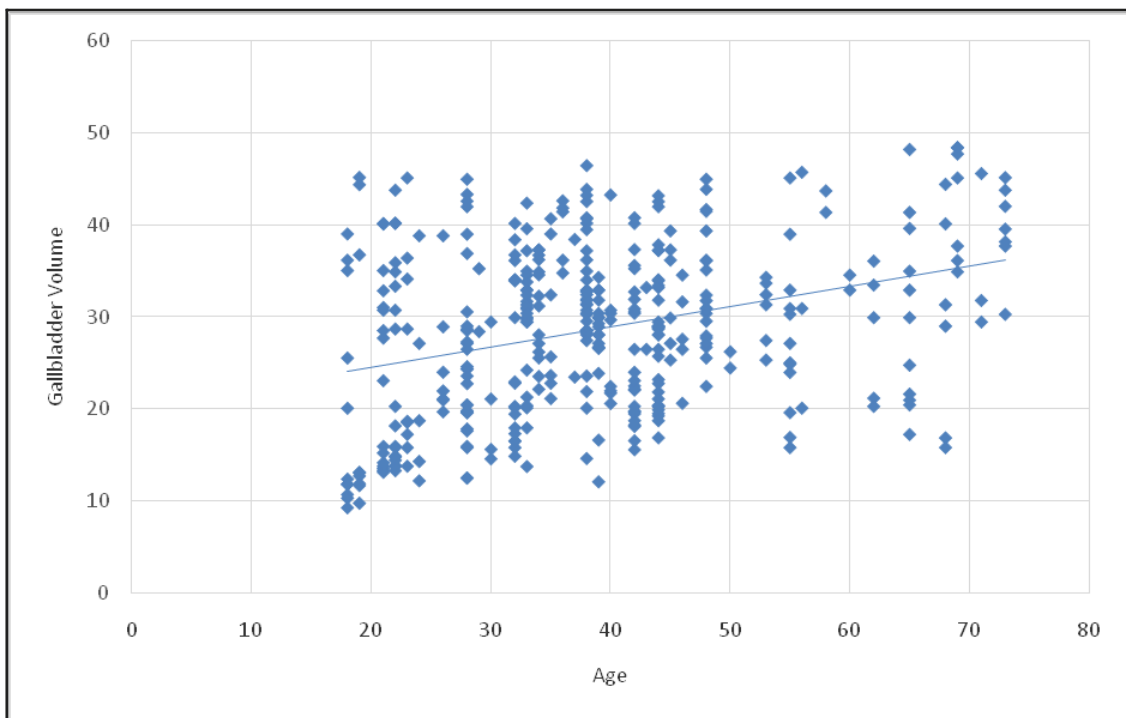


Figure 4 A scatter diagram showing linear relation between gallbladder volume and age of participants

Discussion

This study included 400 cases, with male preponderance (male 62%, female 38%). Two similar studies with male preponderance were conducted by Ewunonu and Idris et al.^{10,11} where 31 males and 29 females, and 238 males and 162 females were scanned respectively. The sex and age distribution of subjects in a pilot study by Ugwu et al.¹² on the quantification of gallbladder volume to establish baseline contraction indices of 50 healthy Nigerian adults comprising 29 males and 21 females with age range 18-62 years is similar to our study. However, the results are contrary to the study by Adeyekun et al.¹³ where 133 males and 189 females were scanned.

In this study, there was a slight difference between values of gallbladder volume and gender. The finding of mean fasting gallbladder volume (29.87%) for males and (26.57%) for females is very approximate values were reported by Adeyekun in South-south Nigeria¹³ with the reported value of 27.2±12.8 cm. A lower value of mean gallbladder volume (24.2±8.4cm) was reported by Idris et al.¹¹ in northwest Nigeria. Huang et al.¹⁴ in Egypt documented a mean gallbladder volume of 28.2 cm. Though the study sample differs from the mentioned studies, there is a slight variation in gallbladder Volume between different ethnic groups.

In this study, the mean gallbladder wall thickness was 2.53mm±0.26 for males and 2.46mm±0.28 for females. Variable ranges of 1.7-2.7 mm are reported by Adeyekun et al.,¹³ Mohammed et al.,⁹ and Ewunonu.¹⁰ In this study, there was a statistically significant difference in gallbladder volume and gallbladder wall thickness between males and females. Males had higher values than females.

This is in line with the fact that organ sizes in men are generally larger than those in women. This was further collaborated by Ewunonu.¹⁰ Several studies¹⁵⁻¹⁷ reported that the gallbladder wall is thickened with the age of more than 65 years.

Same studies also reported that males had thicker gallbladder wall than females. Edris et al.¹¹ reported that gallbladder volume and gallbladder wall thickness varies with age, gender and BMI. However, the study of Adeyekun¹³ on the sonographic determination of gallbladder volume and Mohammed et al.⁹ on sonographic gallbladder weight in the normal adult population in Nigeria found no such variation.

In our study, there was a linear relationship between gallbladder volume and the age of subjects. The increased gallbladder volume at higher age brackets is thought to be due to hypocontractility of the gallbladder with consequent decrease in the gallbladder contraction index. This could be attributed to aging, which leads to the replacement of normal muscle fibers with fibrous tissue or differences in hormonal and neurological profiles between the young and the elderly.¹²

This study established a positive linear significant relationship between gallbladder volume and BMI. In contrast, Adeyekun et al.¹³ in their study of sonographic evaluation of gallbladder volume and ejection fraction in obese women without gall stones documented greater fasting gallbladder volume, residual gallbladder volume, and postprandial values with slower emptying rates in obese subjects than in non-obese controls. This explains the reason for higher gallbladder volume in patients with high BMI. A study by Ugwu¹² from Nigeria showed a relationship between BMI and gallbladder volume.

Conclusion

Slight differences between gallbladder volume and wall thickness values was found in correlation with the gender and age of participants. Gallbladder volume increases with increasing age and BMI.

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Not applicable.

Competing interests

The authors declare that they have no competing interests.

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