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Correlation of Sonographic Measurements of the Gallbladder and somatometric variables in Primary School Age Pupils in Nigeria

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Abstract

Background: Abdominal ultrasound remains a vital and first choice imaging modality utilized in evaluation of gallbladder (GB) pathologies in children. With increasing report of shift in children nutritional habit and childhood obesity over the past few decades reportedly associated with increasing children and adolescents gallbladder diseases, the need to establish a sonographic normogram of GB in our locality for early detection and follow-up on children GB diseases is paramount. Objective: We aim to determine mean values for the GB size among primary school age pupils in Nigeria using ultrasonography and establish the association between GB parameters and subjects' age, sex, height, weight and body mass index (BMI). Methods: A prospective cross-sectional study of 400 apparently healthy primary school age pupils in selected schools, who met the inclusion criteria, was carried out. Uni-dimensional measurements of the maximal GB length, width and height dimensions were obtained. The volume of the GB in cm 3 was calculated from the ellipsoid formula. The subjects' height, weight, and BMI were measured using standard anthropometric technique. Results: GB length, height, width and volume in the studied population were 54.27 ± 6.80mm (Range: 37.0-75.0mm), 21.53 ± 2.93mm (Range:14.0-31.0mm), 23.46 ± 3.11mm (Range:16.0-36.0mm), 14.92 ± 5.51cm3 (Range: 4.3-38.7cm3) respectively. Gallbladder measurements correlated strongly with age, weight, height, and BMI. There was no significant correlation between gallbladder measurements and gender.

Conclusion: Our study established a mean gallbladder size among healthy primary school age pupils in Nigeria. The gallbladder significantly increased in size as age and somatometric parameters increased with no significant difference in gallbladder size in relation to gender.

Keywords: Ultrasound; Gallbladder; School pupils

Introduction

The gallbladder (GB) is a pear-shaped structure located at the fossa on the visceral surface of the liver which store and concentrate bile for release into the duodenum for fat emulsification during digestion [1]. Its wall thickness is affected by degree of contractility and distension [2]. Many disease conditions affect GB volume and contractility including cholecystitis, choledocholithiasis, obstructive pancreatic lesions, diabetes, among others [3]. Cholecystitis is inflammation of the GB and is often associated with cholelithiasis. There seems to be an increase in pediatric laparoscopic cholecystectomies over the past few decades for calculous and acalculous cholecystitis [4-8]. Adenocarcinoma of GB is rare, usually secondary to impacted gallstone, GB polyps, and porcelain GB. Obesity has been reported as leading cause of gallbladder disease in children [9]. The epidemic extreme childhood obesity [10,11], presumably due to shift in nutritional habit may lead to increasing children and adolescents gallbladder diseases. Although obesity is a common cause of gallstone in adult [12], children gallstone, though rare, can be attributed to chronic hemolysis among other risk factors [13,14]. Some works showed that variation in GB volume and risks of GB diseases were associated with ethnicity, age, and gender difference [15,16]. Abdominal ultrasound is employed as first choice radiological investigation in of GB pathologies widely because it is non- invasive, inexpensive, readily available with no risk of radiation effect or adverse effect of contrast agent compared to other modalities [17,18]. Other imaging modalities available for assessing the GB include cholecystography, computed tomography and magnetic resonance imaging [19,20].

Reviewed literature showed some works on sonographic assessment of GB dimensions, including wall thickness and volume in adult Nigerian population [3,21-23]. While normal ultrasound measurement of the gallbladder (GB) is well established in adults, little attention has been focused on the normal measurement of the pediatric gallbladder in spite of reported increase in incidence

pediatric GB diseases. Therefore, it is justifiable to determine normal GB biometry to be used as local reference values for children population in Nigeria.

Methods

A prospective cross-sectional study design was adopted. 400 apparently healthy primary school age children selected from different schools through convenience sampling technique underwent abdominal ultrasound scan. Appropriate ethical approval was obtained from Research and Ethics committee. Informed consent was obtained from the Parents and Teachers Association (PTA) and the children that volunteered to participate in the study. Children privacy guideline and school regulations were observed. Our inclusion criteria were school pupils between 6-12 years of age as prescribed by Federal Republic of Nigeria, (2004) National Policy on Education [24], pupils diagnosed to have normal gallbladder distension with no underlying pathologies that could affect gallbladder parameters.

A single ultrasound machine SonoAce X8 (Medison Inc; Korea) manufactured in 2008 with 3.5MHZ curvilinear transducer was used in this study. In addition to maintenance that was performed by a medical physicist, the transducer gain control was adjusted to optimize visualization of the entire GB. Measurement of GB dimensions was done on each subject with the subject in the supine position, and transducer placed over the right hypochondrial area, in the midclavicular line and angled cephalad in both longitudinal and transverse planes [20]. After visualisation of the maximal GB longitudinal outline, the length was measured on arrested respiration (Figure 1). Subsequently, the probe was rotated through 90° to obtain the maximal width and height dimensions, with calipers crossing each other at 90° as referenced by Idris et al. [22] (Figure 2). Since the shape of the GB was considered as an ellipse, the volume of the GB in cm^3 was calculated from the ellipsoid formula; thus:

Volume of gallbladder (V) = Length (L) × Width (W) × Height (H) × π/6

V = L × W × H × 0.52 (17, 25, 26, 22).

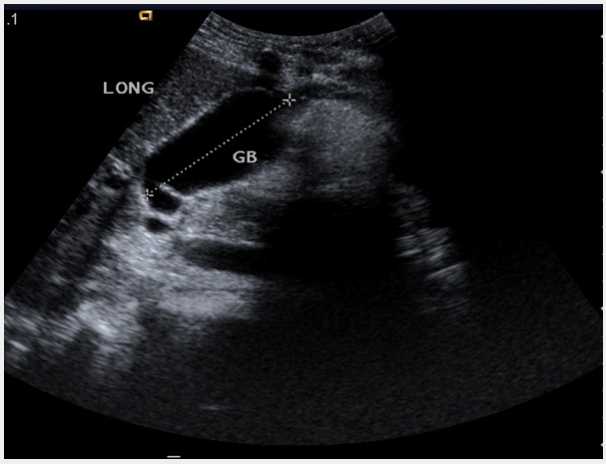

Figure 1: Longitudinal abdominal ultrasound scan image showing the measurement of gallbladder length.

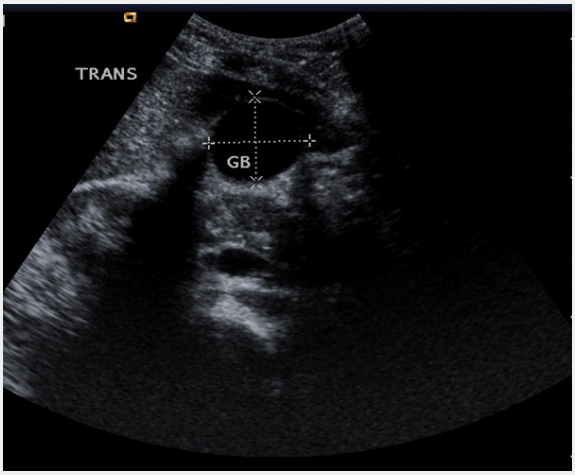

Figure 2: Transverse abdominal ultrasound scan image showing the measurement of gallbladder width and height.

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Each participant's height and weight were obtained. Body weight measurement was made with a weight scale (RGZ- 160) manufactured in the year 2015 by Health & Medical Equipment, England. Its weight range is 0 -160 kgs. Standing height was measured with a stadiometer (seca 213) manufactured in the year 2008 by seca gmbh & co.kg, Germany. The measuring range in cm is 20-205cm. All the measurements were documented in a prepared data sheet. All data including the subject's age and sex, height, weight, BMI, gallbladder length, height, width and volume were analysed using SPSS version 27 for windows. Descriptive statistics, mean ± standard deviation (SD), maximal (Max), and minimal (Min) values were used. Independent samples t- test was used to estimate the sex-related differences. Pearson's correlation coefficient was used to evaluate the correlations of the gallbladder length, height, width and volume with the subject's age, and parameters of body character. P-value of less than 0.05 was considered to be statistically significant. Linear regression equations between the variables were obtained.

Results

Table 1 showed that the mean height, weight, and BMI of the subjects were 137cm, 32Kg, and 17 Kg/cm^2 respectively.

Table 2 showed mean gallbladder length, height, width and volume in the studied population were 25.10mm, 15.98mm and 13.50mm respectively.

Table 1: Age, height, weight, BMI of the pupils.

AGE	N	Height(cm)	Weight (Kg)	BMI
		Mean±SD	Mean±SD	Mean±SD
6	48	125.019±2.5921	24.773±1.0780	15.829±0.5136
7	74	129.028±2.5806	26.593±1.1943	15.954±0.5440
8	59	133.836±3.1319	29.517±1.3181	16.453±0.5263
9	77	138.738±2.2559	33.764±1.6644	17.500±0.6171
10	67	142.457±3.0903	35.312±2.2243	17.367±0.5698
11	52	147.796±2.6584	38.329±2.3652	17.502±0.7437
12	23	151.930±2.6523	40.587±2.3348	17.543±0.7458
Total	400	137.131±8.4509	31.977±5.2479	16.840±0.9274

Table 2: Age of pupils and dimensions of GB size.

Age (Yrs)	N	GB Length(mm)		GB Height(mm)		GB Width(mm)		GB Volume(cm^3)	
		Mean±SD	95% C.I	Mean±SD	95% C.I	Mean±SD	95% C.I	Mean±SD	95% C.I
6	48	47.97 ±4.34	46.72-49.24	18.56±2.34	17.88-19.24	20.44±2.55	19.69-21.18	9.80±3.46	8.79-10.80
7	74	51.46±6.34	49.99-52.93	20.34±2.71	19.71-20.97	22.32±2.79	21.67-22.97	12.69±4.64	11.62-13.76
8	59	55.10±6.31	53.46-56.75	21.73±2.37	21.11-22.34	23.73±2.39	23.10-24.35	15.23±4.59	14.03-16.43
9	77	56.55±5.78	55.23-57.86	22.56±2.09	22.08-23.03	24.29±2.25	23.77-24.79	16.49±4.45	15.49-17.51
10	67	55.63±5.91	54.19-57.07	22.03±2.41	21.44-22.62	24.15±3.19	23.37-24.93	15.86±4.74	14.70-17.02
11	52	55.96±7.46	53.88-58.04	22.48±3.37	21.54-23.42	24.31±3.25	23.40-25.21	16.75±6.35	14.98-18.52
12	23	58.96±6.56	56.12-61.79	23.96±3.01	22.65-25.25	25.96±3.35	24.50-27.41	19.81±7.02	16.77-22.85
Total	400	54.27±6.80	53.60-54.94	21.53±2.93	21.24-21.82	23.46±3.11	23.15-23.76	14.92±5.51	14.37-15.46

From the correlation analysis in Table 3, it can be deduced that there was strong correlation between the age, height, weight and BMI of the studied population and all the measured gallbladder parameters (length, height, width and volume), ($p < 0.01$). Linear regression equations established that there is linear relationship between measures gallbladder parameters and subjects' age (years), height (cm), weight (Kg), and BMI.

GB length = 41.15 + 1.5 x Age

GB width = 17.16 + 0.72 x Age

GB height = 15.25 + 0.72 x Age

GB volume = 3.38 + 1.32 x Age

Independent Samples T-Test performed between GB (Volume and Length), and gender showed no significant relationship between GB (Volume and Length) and gender. Correlation is significant at the 0.05 level (Table 4).

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Table 3: Pearson Correlation between GB parameters and variables.

Variables	GB Length	GB Height	GB Width	GB Volume
Age	0.000**	0.000**	0.000**	0.000**
Height	0.000**	0.000**	0.000**	0.000**
Weight	0.000**	0.000**	0.000**	0.000**
BMI	0.000**	0.000**	0.000**	0.000**

Table 4: Independent Samples T-Test between GB (Volume and Length) & gender.

	Male	Female	T-test	P value
GB Length	53.761±6.2690	54.691±7.2000	-1.361	0.174
GB Volume	14.490±4.9582	15.271±5.9029	-1.415	0.158

Discussion

Clinical examination of gallbladder is not sensitive in diagnosis of pathology. Abdominal ultrasound is widely employed in evaluation of GB pathologies widely because it is non- invasive, inexpensive, readily available with no risk of radiation effect or adverse effect of contrast agent compared to other modalities [17,18]. Other imaging modalities available for assessing the GB include cholecystography, computed tomography and magnetic resonance imaging [19,20].

This study was carried out to determine normal sonographic gallbladder biometry in primary school age pupils in Nigeria to be considered as local reference guidelines for accurate diagnosis, treatment monitoring and research on GB related pathologies. We equally correlated the GB measurements with physical data such as gender, age, height, weight, BMI. The sample size for this study consisted of 400 subjects. Ellipsoid formula was employed for calculation of GB volume because it was the most commonly established and accurate method [17,25,26].

Mean GB length, height, width and volume in the studied population were established (Table 2). Yoo et al. [26] showed similar mean GB length results but differed slightly in GB length, height, width and volume. They included a total of 610 subjects to sonographically establish the range of sonographic measurements of normal gallbladders in children 0-16 years. Gallbladder length ranged from 2.5 to 8.9 cm (mean, 5.3 ± 1.3 cm), gallbladder width from 0.1 to 3.4 cm (mean, 1.7 ± 0.5 cm), and gallbladder volume from 0.3 to 42.0 cm^3 (mean, 8.0 ± 6.1 cm^3). The similarity could be attributed to similar nature of studied population (children). The difference could be due to wider age range (0-16 years), and different ethnicity. Caroli-Bosc et al. [27], Adeyekun & Ukadike [21], Oluseyi [28], Idris et al. [22] reports differed from the result of this study. The differences could largely be attributed to dissimilar study population (adults) and difference in ethnicity. The gallbladder size parameters in this study showed a strong significant positive correlation with age and all body parameters ($p < 0.01$) as shown in Table 4 [3]. These findings were in line with those of Palasciano et al. [12], Yoo et al. [12], Caroli-Bosc et al. [27], Yoo et al. [26], Idris et al. [22]. However, Adeyekun & Ukadike [21] stated that age did not significantly influence GB measurements.

The findings of Adeyekun & Ukadike [21] showed no significant correlation between GB measurements and gender in keeping with the result of this work (Table 4). Caroli-Bosc et al. [27], Palasciano et al. [12], Oluseyi [28], Idris et al. [22], however stated that GB measurements differed significantly with gender. The relation between GB parameters and age was best described by established linear regression equations. These equations will provide immediate and approximate calculation of GB parameters in day-to-day clinical practice in Nigeria. Therefore, this study has shown that a clinician who knows the age or measures any somatometric parameters such as weight or height could actually estimate gallbladder length to a reasonable degree of certainty using appropriate regression equation. This is possible because this study has shown that as age increased (and of course, as weight and height increased), gallbladder length increased.

Conclusion

Our study established a mean gallbladder size among healthy primary school age pupils in Nigeria. The gallbladder significantly increased in size as age and somatometric parameters increased with no significant difference in gallbladder size in relation to gender.

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