ORIGINAL ARTICLE

SONOGRAPHIC EVALUATION OF THE COMMON BILE DUCT SIZE IN NORMAL ADULTS AT UNIVERSITY OF MAIDUGURI TEACHING HOSPITAL, NIGERIA

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ABSTRACT

Background: Despite ultrasound safety, affordability and its widespread use in evaluation of the diseases of biliary tree, paucity of literature on the sonographic measurements of the size of the normal adult common bile duct (CBD) in this environment exists. Objectives: To determine the normal adult diameter of the CBD in this environment using ultrasonography. Methods: This was a cross-sectional prospective study carried out at the University of Maiduguri Teaching Hospital between January to June, 2011. Results: There were 224(56%) females and 176(44%) males aged between18 and 87 years (Mean±SD, 36.88 ±16.97 years). The mean AP and transverse CBD diameters (±SD) were 3.68±0.82mm and 3.89±0.86mm, respectively. The average mean for the two measurements (± SD) was 3.78±0.84mm (range = 2.0 – 6.0 mm). The mean transverse diameter was slightly greater than AP diameter (p = 0.0004).The CBD diameter was strongly correlated with age (r = 0.798; p = 0.000; r^2 = 0.629). The least squares regression slope of 0.039mm±0.001 (mean±SD) was obtained suggesting 0.039mm±0.001 increase in the CBD diameter per year. There was significant correlation between the CBD diameter with weight (r = 0.504; p = 0.000) and BMI (r = 0.454; p = 0.000). No significant difference between the mean CBD diameter in males and females (p= 0.084)was observed. Conclusion: The mean and range of CBD size in normal adult population were determined and significantly correlated with age, weight, and BMI.

Keywords: Sonography, Common bile duct, Normal adult

INTRODUCTION

The common bile duct (CBD) is a part of network of structures known collectively as biliary tree, which drains bile from the liver into the second part of the duodenum. It begins at the level where cystic duct joins the common hepatic duct (CHD) and unites distally with the pancreatic duct in a dilated ampulla. The biliary tree also includes the gall bladder, the cystic duct, the right and left hepatic ducts and the common hepatic duct, as well as a series of microscopic biliary ducts within the liver.

Ultrasonography has evolved as the primary imaging modality for measuring

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the size of the CBD. The determination of adult CBD duct size and its variations with age, gender, body mass index (BMI),[1-7] post cholecystectomy[8-10] and changes with respiration[11] have been determined in other studies using ultrasound. These studies show wide range of variations and the acceptable upper limit of normal diameter has varied greatly. Literature suggests that the upper limit of up to 7mm in young adult is considered normal.[2] This study therefore is aimed at determining the duct diameter in healthy adult population. The findings of this research would assist clinicians to objectively assess the changes in calibre of CBD in biliary disease.

MATERIALS AND METHODS

This was across-sectional prospective study that was conducted in the Department of Radiology, University of Maiduguri Teaching Hospital. The study cohorts consisted of all eligible subjects who were referred for radiologic examination unrelated to hepatobiliary or pancreatic disease based on clinical and laboratory assessment between January and June 2011.

Imaging protocol: A brief history to include previous history of hepatobiliary and pancreatic disease or surgery and physical assessment of the subjects for surgical scars and jaundice not accounted for in the history and laboratory findings of liver function test were done prior to the examination. Clinical parameters which included age, gender, height and weight were recorded for each subject. The body mass index (BMI) which was calculated as the ratio of the measured weight to the square of the measured height (kg/m^2) was also calculated for each subject.

The examinations were performed using a high-resolution Aloka, SSD-3500 ultrasound scan machine equipped with 3.5 and 5.0 MHz curvilinear array transducer. The 3.5 MHz curvilinear array transducer generally provides optimum resolution while maintaining adequate depth penetration and is suitable for thick subjects. A 5.0 MHz curvilinear array transducer provides greater resolution for slim subjects.

All study participants were asked to fast for at least 6 to 8 hours since fasting state distends the gallbladder and the bile ducts and reduces bowel gas that may obscure visualization of the CBD. They were told not to smoke cigarette during the fasting period because nicotine is known to cause smooth muscle contraction.

Routine ultrasound of the liver was carried out before starting CBD evaluation. Subjects were excluded from the study if they had an incidental hepatomegaly (liver span $\geq$ 15cm). The CBD was imaged in subcostal or intercostal approach with the patient either in supine, right anterior oblique, left posterior oblique, left lateral decubitus or upright positions as needed. Both longitudinal and transverse imaging planes were used. The choice of optimal technique depended on differences in anatomy, body habitus, and overlying bowel gas.

Since the CHD and the proximal CBD courses in a plane that is somewhat perpendicular to the right costal margin, a parasagittal plane with transducer angled from the right shoulder to the left hip was done to enhance their visualization. Turning the subject up toward his or her left side (into a left posterior oblique position) using liver as an acoustic window was also helpful for easy identification. This transducer angulation allowed visualization of the proximal

CBD anterior to the main portal vein in most cases. If the duct was still not well visualized, the subject was turned all the way on his or her side into a left lateral decubitus position and then imaged.

The axis of the CBD usually changes from oblique to sagittal at the superior margin of the pancreas. The distal CBD was then demonstrated in the sagittal plane, angling under the duodenum if necessary, to see the proximal intrapancreatic portion. At this point the duct curves laterally and eventually disappears into the sphincter of Oddi.

Where gas in the duodenum and antrum obscured the distal CBD, placing the patient in an erect right posterior oblique position helped to displace the air. If bowel gas interference still existed, the subject was asked to drink about 35cl to 50cl of water and rest in a right lateral decubitus position for at least 2 to 3 minutes. This helped to displace the gas in the duodenum and also provided an acoustic window.

The best way to evaluate the CBD is in the long-axis view anterior to the portal vein. However, transverse view was obtained by rotating the transducer 90 degrees from its long axis view without changing the position of the transducer to give a typical 'Mickey Mouse' sign. The CBD and hepatic artery forming the ears of the Mickey Mouse while the large portal vein represents the face. Suspicious tubular structures were traced to their origin to ensure that they were part of the bile ducts and not arteries. Colour or pulsed Doppler interrogation was also employed to determine whether a structure was a vessel or a duct.

The CBD internal diameter in long axis and transverse views were measured. The AP diameter from anterior to posterior wall was obtained from the longitudinal images (Figure 1). The transverse diameter from medial to lateral wall was obtained from the transverse images (Figure 2). The average of the two measurements was used to determine the final duct size. All measurements were made from inner wall to inner wall of the ducts using electronic caliper at a fixed measurement point at least 2cm above the head of the pancreas. The most easily identified part of the CBD.

Data analysis

The data obtained from the structured data sheet was entered into a computer system and analysed using Statistical Package for Social Science Software (SPSS version 16.0 Chicago, IL, USA). The results were expressed as mean ±standard deviation (SD) and presented in the form of tables, charts and graphs as appropriate.

Statistical significance was assessed using student t-test to compare the mean CBD diameter between two sexes and to compare the difference between the mean AP and transverse CBD diameters. Correlation between the CBD diameter with weight, BMI and height were evaluated using Pearson's correlation test. Simple linear regression was used to correlate patient age and CBD diameter. The mean CBD diameter was used as a dependent variable, and age was used as an independent variable. P value less than 0.05 was considered statistically significant.

RESULTS

A total of 400 hundred subjects (224 women and 176 men) were prospectively evaluated with ultrasound. They were aged between 18 and 87 (mean age: 36.9 ± 16.97)[Figure3]. More than a half of study population (62%) were between the ages

Table 1: Age group & gender distribution of the sample population

Age group(years)	Females N (%)	Males N (%)	Total N (%)
18-27	98(24.50)	50(12.50)	148(37.00)
28-37	55(13.75)	45(11.25)	100(25.00)
38-47	30(7.50)	26(6.50)	56(14.00)
48-57	20(5.00)	16(4.00)	36(9.00)
58-67	9(2.25)	19(4.75)	28(7.00)
68-77	7(1.75)	13(3.25)	20(5.00)
78-87	5(1.25)	7(1.75)	12(3.00)
Total	224(56)	176(44)	400(100)

Table 2: Mean CBD sizes in various age groups

Age group (Years)	AP-diameter (mm) (Mean ± SD)	Transverse diameter(mm) (Mean ± SD)	Average diameter (mm) (Mean ± SD)	Wall thickness (Mean±SD)
18-27	3.02 ± 0.48	3.20 ± 0.51	3.12 ± 0.48	1.04 ± 0.17
28-37	3.55 ± 0.45	3.75 ± 0.51	3.64 ± 0.47	1.14 ± 0.21
38-47	4.00 ± 0.47	4.25 ± 0.50	4.13 ± 0.47	1.19 ± 0.20
48-57	4.32 ± 0.53	4.49 ± 0.55	4.41 ± 0.54	1.15 ± 0.17
58-67	4.52 ± 0.56	4.76 ± 0.57	4.63 ± 0.59	1.22 ± 0.21
68-77	5.10 ± 0.61	5.35 ± 0.63	5.23 ± 0.62	1.18 ± 0.21
78-87	5.11 ± 0.82	5.41 ± 0.83	5.26 ± 0.83	1.13 ± 0.17
Overall	3.68 ± 0.82	3.89 ± 0.86	3.78 ± 0.84	1.12 ± 0.20

SD= standard deviation AP=anteroposterior

Table 3: Correlation between the mean CBD diameter with BMI, height and weight.

	Pearson Correlation	
	Correlation Coefficient(r)	P-value
BMI	0.454	0.000
Weight(kg)	0.504	0.000
Height(m)	0.152	0.002

Table 4: Gender and the overall mean and range of the CBD size

Sex(N)		APD(mm)	TRD(mm)	AveD(mm)
Females (224)	Mean(±SD)	3.61±0.82	3.82 ±0.86	3.72±0.84
	Range	2.0-6.0	2.0-6.2	2.0-6.0
Males(176)	Mean(±SD)	3.76± 0.82	4.00± 0.85	3.86±0.83
	Range	2.1-5.9	2.3-6.1	2.2-6.0

APD = anteroposterior diameter, TRD =transverse diameter AveD= average diameter

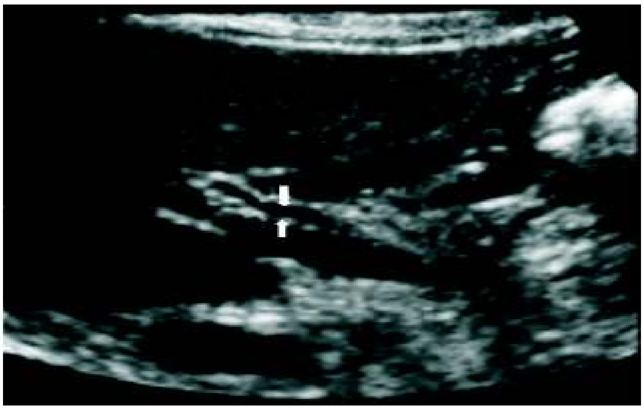

Figure 1: Longitudinal sonogram of the CBD showing method of measurement of the anteroposterior diameter from anterior inner wall to proximal inner wall (arrows).

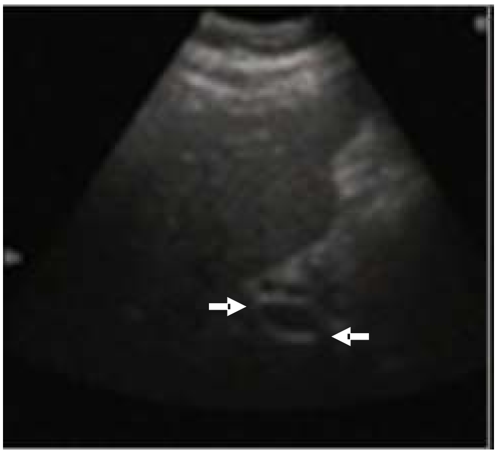

Figure 2: Transverse sonogram of the CBD showing method of measurement of the transverse diameter from medial inner wall to lateral inner wall (arrows).

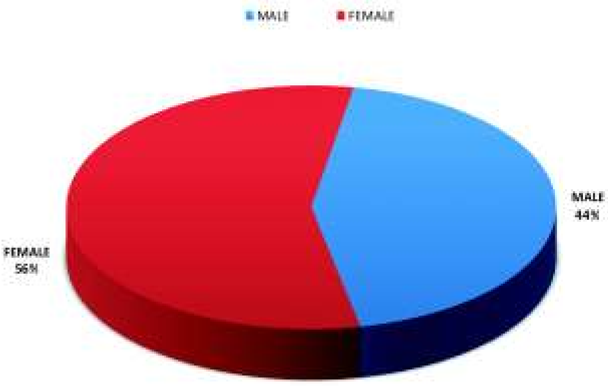

Figure 3: Gender distribution of the study population

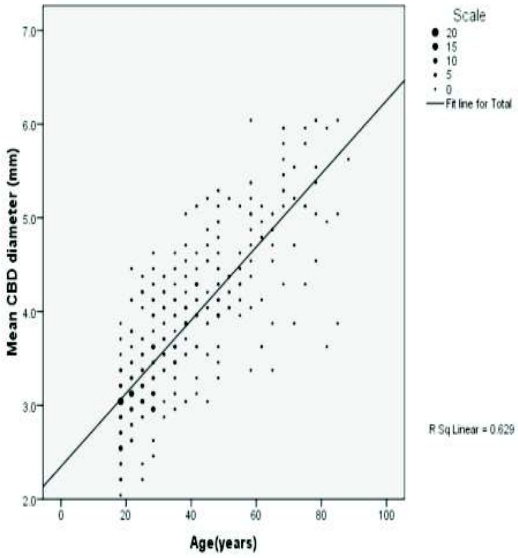

Figure 4: Scatter plot diagram showing correlation between the CBD diameter and age of the subjects.

The range of AP diameter of the CBD was 2.0 to 6.0 mm (mean= 3.68 ± 0.82 mm) and that of transverse diameter was 2.0-6.2 mm (Mean = 3.89±0.86mm). The average mean transverse diameter was slightly greater than the mean AP diameter (P = 0.0004). The overall range of CBD diameter was 2.0 – 6.0 mm (mean = 3.78±0.84 mm).

There was gradual increase in the CBD diameter with increasing age. The mean CBD diameter increased from 3.12mm±0.48 in the age group 18-27 years to 5.26mm±0.83 in the age group 78-87years(Table 2).A simple linear regression analysis showed strong positive correlation between the mean CBD diameter and the age (r = 0.798; p = 0.000; r^2 = 0.629). The least squares regression slope of 0.039mm±0.001 (mean±SE) was obtained suggesting a gradual increase in the CBD diameter by 0.039mm±0.001 per year (0.39mm±0.01 per decade)[Figure 4]

There was statistically significant correlation between the CBD diameter with weight (r = 0.504; p = 0.000) and BMI (r = 0.454; p = 0.000) with no significant relationship noted with height of subjects (r = 0.152; p = 0.002) [Table 3].

The mean CBD diameter was 3.72 mm ± 0.84 (range = 2.0-6.0 mm) in females and 3.86 ± 0.83 mm (range = 2.2-6.0 mm) in males. There was no significant difference between the average mean CBD diameter in males and that of females (p= 0.084) [Table 4].The wall thickness of the of the CBD measured between 0.7mm and 1.5mm (mean = 1.12 ± 0.2mm).

DISCUSSION

Themeasurement of common bile duct diameter is an important component of the evaluation of the biliary system as the size of the common bile duct diameter is a predictor of biliary obstructionor choledocholithiasis.[12,13-15] Several studies have been carried out quantifying the normal calibre of the CBD as measured by ultrasonography show wide range of variations and the acceptable upper limit of normal have varied greatly.[1,3,4,16]

A prospective study of 251 patients between 20and 94 (mean = 52.5 ± 17.63) years of ageby Bacher *et al*[3]showed the range of CBD diameter of 1.0-8.6 mm with the overall mean diameter of 3.60 ± 1.15 mm. In a similar study by Horrow *et al*[4] where they found the overall mean for all measurements of duct diameter of 3.5 ± 1.2 mm and ranged between 1.7-6.0 mm. In another study by Admassie *et al*[17]on ultrasound assessment of common bile duct diameter in Tikur Anbessa Hospital, Addis Ababa, Ethiopia. In his study, he evaluated 293 normal adult patients and found that the range of CBD diameter of 2.1-6.0 mm and mean diameter of 3.90 mm. The overall mean CBD in this study was 3.78 ± 0.84 mm which is in close agreement with the above findings and well in the range of the referenced studies.

This study also showed range of CBD diameter between 2.0 – 6.0 mm which is in close agreement with the findings of Admassie *et al*[17] and that of Horrow *et al*[4] both of which had maximum CBD diameter of 6.0 mm. This study did not find CBD diameter of less than 2 mm or greater than 6 mm in contrast to the findings by Bachar *et al*[3] and Wu *et al*[16]range of CBD diameter of 1.0-8.6 mm and 1.0-10.0 mm respectively.

Wachsberg *et al*[18]found that the duct tended to be oval in shape when dilated, in favour of transverse diameter. Horrow *et al*[4]also observed that non-dilated ducts transverse measurements numerically exceed AP measurements. In contrast, Perret *et al*[2] observed no significant discrepancies in duct size when compared the sagittal (AP) and transverse measurements. In this study, although the difference in the overall mean diameter obtained in AP view and that obtained in transverse view is just 0.21mm, it is statistically significant (P = 0.0004). The mean transverse diameter was greater than AP diameter and this correlates with the findings of Horrow *et al*[4] and Wachsberg *et a.l*[18]

Several studies have shown that the CBD diameter increases with age.[1-3,5-7,16,17,19] In 1984 Wu *et al*[16]established the effect of age on the size of extrahepatic bile ducts. The size of the extrahepatic bile ducts was age dependent. In a study by Bachar *et al*[3] on the effect of aging on the adult extrahepatic bile ducts using ultrasonography. They found significant correlation between CBD size and age. Adibi *et al*[5]evaluated 375 adult patients older than 16 years of age to find out the relationship between the CBD diameter and demographic data (age, gender and

BMI), fasting, and history of opium addiction. They found out that the CBD diameters (proximal and distal) were significantly correlated with age. This study showed strong correlation between the CBD and age ($r = 0.798$; $p = 0.000$; $r^2 = 0.629$). In contrast, Horrow *et al*[4]in a prospective study of 258 patients, failed to observe any increase in size of CBD with age.

A study by Wu et al[16]also observed that the size of the CBD increases by 0.1mm per year or 1mm per decade. Bachar *et al*[3] found that CBD gradually dilated 0.04mm per year (0.4mm per decade). In this study, the least squares regression slope of 0.039 mm ± 0.001 (mean ± SE) was obtained suggesting gradual increase in the CBD diameter by 0.039 mm ± 0.001 per year (0.39 mm ± 0.01 per decade) which is similar to findings of Bachar *et al.*[3] In contrast, Horrow *et al.*[4]did not observe any increase in the CBD size per year or per decade. The enlargement of CBD diameter with increasing age may be explained by fragmentation of the longitudinal smooth myocyte bands and intervening connective tissues, and loss of the reticulo-elastic network of duct wall with aging which leads to reduced contractility and hypotonia of the CBD.[20]

Ultrasonographic studies to ascertain the relationship between the CBD diameter with demographic data (weight, BMI and height) were done by previous researchers.[5-7,17] Daradkeh *et al.*[7]found out that one of the factors significantly affect the diameter of the CBD is BMI. Adibi *et al.*[5]also observed significant correlation between the CBD diameter and BMI. In contrast, Brogni *et al.*[6]did not observe any relationship between BMI and diameter of the CBD. This study is in conformity with findings of Adibi *et al.*[5] and Dardkeh *et al.*[7]as the diameter of the CBD significantly correlated with BMI ($r = 0.454$; $p = 0.000$).The increase in the CBD diameter with increasing BMI or weight is expected because CBD is a part of the body habitus.

Most researchers did not take into consideration weight or height as separate entities for correlation with the diameter of the CBD but rather preferred to correlate with BMI. However, Admassie *et al.*[17] correlated weight and height as separate variables with the diameter of the CBD. He observed that the duct diameter significantly correlated with weight and observed no association with height. This study is consistent with the findings of Admassie *et al.*[17]in that the CBD diameter significantly correlated with weight ($r = 0.504$; $p = 0.000$). Though statistically significant ($p = 0.002$), correlation between diameter of the CBD and height is very weak ($r = 0.152$) in this study.

Many studies did not establish difference in CBD diameter between the two genders.[5-7, 17] This study is similar to the above findings as no significant difference in CBD diameter was found between the two genders ($P = 0.084$).

None of the previous studies conducted showed bile duct wall thickness greater than 1.5 mm.[21-23]Mahour *et al*[22] observed that the CBD wall varied from 0.8 to 1.5 mm (mean=1.1 mm). In a study by Schulte *et al.*[23], the mean wall thickness of the CBD was 1 mm. No duct size measured more than 1.5 mm in their study. Mesenas *et al*[24] in their study: duodenal endoscopic ultrasound (EUS) to identify thickening of the extrahepatic biliary tree wall in primary sclerosing cholangitis; they found 0.8 mm as the mean wall thickness of the CBD in normal control group.

The mean CBD wall thickness obtained in this study was 1.1 mm and varied between

0.7 to 1.5 mm with no duct wall thickness exceeded 1.5 mm.

CONCLUSION

Ultrasonography has become the first-line diagnostic tool for evaluation of suspected biliary pathologies because it is readily available, relatively inexpensive and does not make use of ionizing radiation. With the aid of high-resolutionscanners, the luminal diameter of the CBD can be assessed accurately. The mean CBD size in this environment was found to be 3.78 ± 0.86 mm and ranged between 2.0-6.0 mm. There was significant correlation of the CBD diameter with age, weight, and BMI. No statistically significant difference in the CBD size found between the two genders.

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