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Assessment of Celiac Trunk and Hepatic Artery Dimensions among Hausa Population in Northern Nigeria

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ABSTRACT

Anatomical variations in the celiac trunk and hepatic artery are critical for clinical practice, particularly in regions with unique population characteristics. This study investigated the relationship between celiac trunk, hepatic artery dimensions and their sex differences among Hausa subjects in Northern Nigeria. This cross-sectional study utilized three-dimensional multi-detector computerized tomography data from 93 subjects (48 males and 45 females) aged 25 years and above, collected from Department of Radiology, Aminu Kano Teaching Hospital, Kano State, Nigeria. Measurements of length and diameter of celiac trunk and hepatic artery were taken. The mean length of celiac trunk was 17.65 ± 5.00 mm, and that of common hepatic artery was 27.12 ± 2.85 mm. The mean diameter of the celiac trunk was 7.68 ± 1.88 mm, while that of proper hepatic artery was 5.5 ± 1.02 mm, with significant sex differences observed in all dimensions except for the diameter of the celiac trunk and diameter of proper hepatic. Males generally exhibited higher mean values than females across all parameters. The study found significant sexual dimorphism in the dimensions of the celiac trunk and hepatic artery, with most dimensions correlating positively with each other. These findings underscore the importance of considering sex differences in clinical assessments and interventions within this population.

Keywords: celiac trunk, hepatic artery, dimensions, arterial variants, Hausa

INTRODUCTION

The celiac trunk is the first visceral collateral branch of the abdominal part of the aorta, originating at its anterior contour just below the aortic hiatus of the diaphragm [1]. It is a wide ventral branch of abdominal aorta measuring about 1.25 cm in length and arising just below the aortic hiatus opposite the lower border of T12 and passes almost horizontally forwards and slightly right above the pancreas and splenic vein, dividing into left gastric, splenic and common hepatic arteries [1].

The introduction of laparoscopic cholecystectomy has stimulated a renewed interest in the anatomy of the celiac trunk and hepatic artery [2]. Division or damage with subsequent thrombosis produces ischemia of the liver or bile duct which can have devastating consequences for the patient[2]. Therefore, surgeons performing hepato-biliary surgery must possess a thorough understanding of the celiac trunk, with a particular focus on hepatic artery anatomy, and be able to recognize the various anatomical variants to ensure safe surgery and minimize morbidity[3]. A good knowledge of the coeliac trunk, specifically the hepatic artery anatomy has a significant importance for the daily practice of a wide range of practitioners including not only surgeons specialized in the hepatopancreatobiliary (HPB) region, but also general surgeons and radiologists with keen interest in interventional radiologic treatments.

For effective functioning of the liver, the liver receives dual supply of blood from the hepatic portal vein and hepatic arteries. The hepatic portal vein supplies approximately 75% of required blood to the liver while the arterial supply accounts for the remaining 25% of the blood flow and the oxygen demand is however equally provided by the hepatic portal vein and hepatic arteries[4]. Hepatic vascularization is rich and often present challenges to surgeons during various surgical processes involving liver[4]. The Couinaud's classification which is perhaps the most popular classification of liver anatomy divides the liver into 8 independent segments. The implication of this is that surgical resection of one segment of a liver can be performed independently without injuring the anatomy of adjacent segments especially the vascularization. It is the knowledge of this segmental system that determines the success of resection in surgical procedures.

Strasberg[5] emphasized that a low technological means and relatively reliable method of teaching liver anatomy to medical students is by using the right-hand fist. The right hand is used to make a fist while tucking the thumb behind the remaining fingers. The fist is turned facing the individual and the digits are numbered in the fashion similar to Couinaud's diagram of the liver (Figure 1). The knowledge of this basic rule has been used in classroom for years without access to sophisticated means of obtaining hepatic modeling. The emergence of sophisticated means has clearly shown that the general idea using this method provides limited understanding of liver anatomy and its variation in vascularization and the method is generally insufficient to determine prognosis following surgical intervention[6].

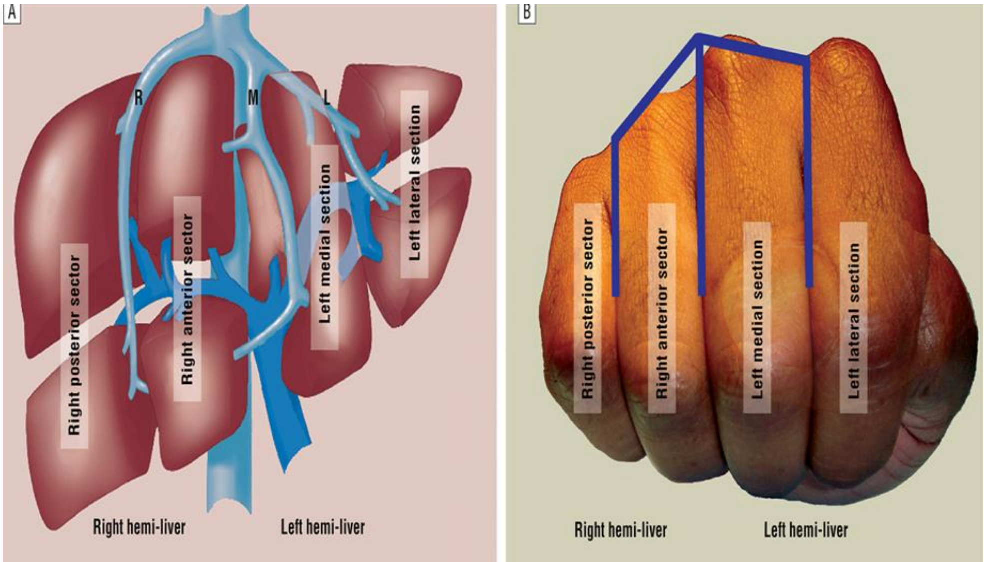

Figure 1: Right Fist Method of Hepatic Segmentation [7].

In recent years, the application of radiographic imaging modalities brings about new dimensions to perception of gross human anatomy in planes resulting in the concept of radiographic/radiological anatomy [8]. Originally, the complexity of the internal vascular and biliary system of the liver forms the intricacies in studying the hepatobiliary system. These intricacies are further complicated by the difficulties encountered when visualizing and interpreting liver anatomy using two-dimensional (2D) ultrasonography, computerized tomography (CT), magnetic resonance imaging (MRI) and plane radiography which are all branches of radiographic methods and all present complex spatial resolutions in viewing liver anatomy [6]. Hence the need to develop a three-dimensional (3D) method of viewing the liver. The 3D view of the complex anatomy of the hepatobiliary system is still presented with challenges in all the imaging modality except in the CT where reconstruction is suitable and superior to other imaging methods due to its nature of high technological tools. For instance, the limitations in use of sound energies in penetrating deep structures in body organ consequently limits ultrasound in obtaining the best possible images of deep structures of the liver during 3D study [8]. Hence, the suitability of 3D multi-detector computerized tomography (3DMDCT) in studying vascularization of the liver becomes significant. The 3DMDCT allows for 100% visualization of the liver surface, portal vein, hepatic arteries, hepatic veins and biliary system. This imaging modality will obviously be suitable to examine anatomical variation of hepatic arteries in a given population and therefore readily applicable to establish individual arterial patterns [9].

The close relationship between celiac trunk, hepatic arterial system and some medical conditions such as hepato-biliary tumors, splenic aneurysm, pancreatic carcinoma, celiac axis compression syndrome, gastric carcinoma and mesenteric ischemia prompted the study particularly in locality were such diseases do occur. Radiologists are faced with problems of deciding whether coeliac trunk and hepatic arteries are within normal limits or enlarged for a patient’s age. This has been a subjective decision based on experience. Although several studies have been reported on variations in hepatic arterial pattern in UK, US, India and even among Africans predominantly with the use of cadaver[6,8,9], there may be misdiagnosis resulting from judgmental errors with regards to our study population as there is scarce literature which can be used as reference for celiac trunk and hepatic arterial system dimensions of Hausa ethnic group of Northern Nigeria.

MATERIALS AND METHODS

The study focused on the 3D MDCT of subjects who underwent abdominal CT scan in the Radiology Department of Aminu Kano Teaching Hospital (AKTH), Kano, northwestern region of Nigeria. Kano is on a latitude of 12º 37/North, 9º 33/South and 7º 43/ West and is bordered on the East by Bauchi and Jigawa States, to the South by Kaduna state and to the West and North by Katsina State with a total land area of 20,760sq km. The AKTH is the only teaching hospital in the state and serves as a referral hospital for both private and established hospitals from the population of States around its border.

The study population comprises subjects that are of Hausa ethnicity of Nigerian origin. Abdominal contrasts-enhanced MDCT images of male and female subjects of age limits from 25 years and above were selected for the study, while images of subjects below 25 years of age and subjects diagnosed with hepatic and or vascular disease conditions were excluded. A total of 93 Subjects (48 males, 45 females) were selected from CT Vitrea of AKTH, having obtained ethical clearance from the Ethics and Research Committee of AKTH, with sample size taken based on previous studies. Definite criteria for selection of images to ensure accuracy was followed based on the inclusion and exclusion criteria stated below while validation of data was ensured through the assistance of radiologists/radiographers in the Department.

Inclusion Criteria

- CT images that presented both normal architecture and vascular anatomy of the liver.
- Images which were taken using Field of View (FOV) that extends from the level of xphisternum to symphisis pubis.
- Images that have good image quality by tri-phasic method of image acquisition (distinct and clear limits of hepatic arterial vessels) were used.
- Subjects within the age of 25 to 70 years.

Exclusion Criteria

- CT images that presented both abnormal architecture and vascular anatomy of the liver.
- Images which were not taken using Field of View (FOV) that extends from the levels of xiphisternum to symphisis pubis.
- Images that have poor image quality by tri-phasic method of image acquisition (distinct and clear limits of hepatic arterial vessels) were used.
- Subjects out of the age range of 25 to 70 years.

The images were obtained from Toshiba CT scanner of 164 slice installed at AKTH. The Vitrea software package in the workstation was used as advanced visualization software to process vital images of interest to create 3D images of hepatic anatomy from CT image data. The created 3D images were displayed on the visual displayed unit (VDU). With this productivity-enhancing tool, it was easy to create and visualize hepatic arterial pattern of individual Subjects for successful classification (Figure 2). The length of the coeliac trunk, common hepatic artery and proper hepatic artery were measured as well as the diameter of coeliac trunk and hepatic arterial system.

The data from the 3D images were analyzed using SPSS version 21.0 statistical packages. Descriptive statistics, mean and standard deviation were utilised and all the variables measured in males and females were tested for significant differences using independent samples test. Cross tab with chi – square test was used to evaluate the variant hepatic arterial system. Correlation of bivariate was used and $p < 0.05$ was considered significant.

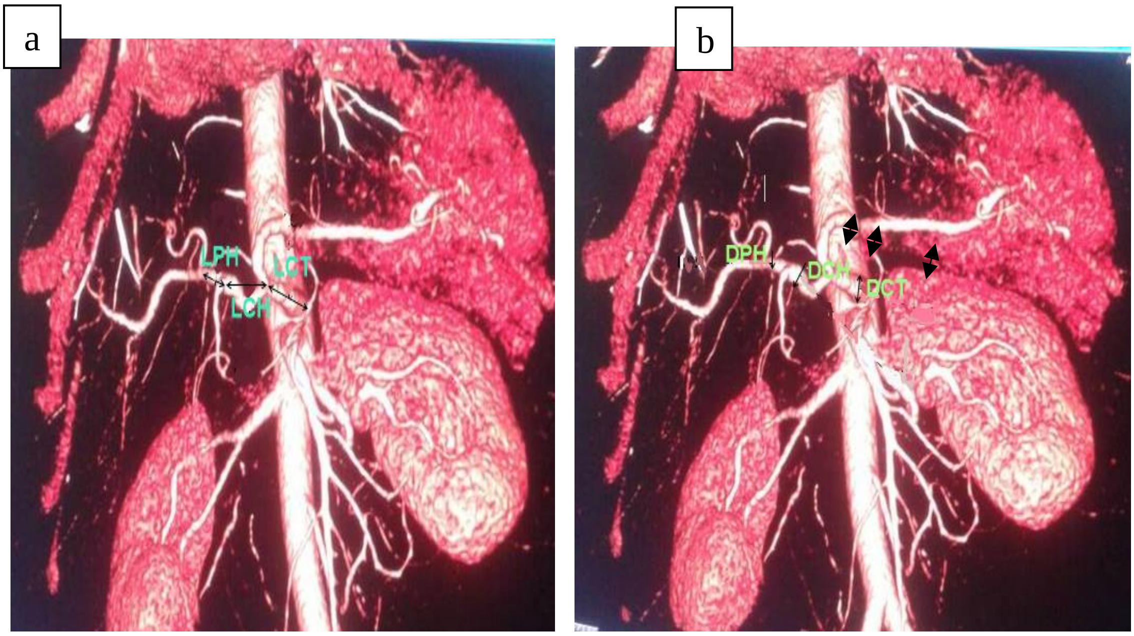

Figure 2: Measured **d**imensions and their landmarks or celiac trunk and hepatic arterial system**. A:** LCT = length of celiac trunk, LCH = length of common hepatic artery, LPH = length of proper hepatic artery. **B:** DCT = diameter of celiac trunk, DCH = diameter of common hepatic artery, DPH = diameter of proper hepatic artery.

RESULTS

Celiac Trunk and Hepatic Artery Dimensions

The descriptive statistics of the celiac trunk and hepatic artery revealed that the mean for the length of celiac trunk was 17.65 ± 5.00 mm and the mean of length of common hepatic artery was 27.12 ± 2.85 mm, whereas the mean diameter of celiac trunk was 7.68 ± 1.88 mm and 5.5 ± 1.02 mm mean diameter for proper hepatic artery (Figure 1).

Table 1: Descriptive statistics for coeliac trunk and hepatic artery lengths and diameters (n=93)

Variables (mm)	Mean ± SD	Range	Minimum	Maximum
LCT	17.65 ± 5.00	24.00	7.60	31.60
LCH	27.12 ± 2.85	15.30	19.80	35.10
LPH	19.79 ± 1.97	8.90	14.90	23.80
DCT	7.68 ± 1.88	6.60	4.50	11.10
DCH	6.65 ± 1.19	5.50	3.60	9.10
DPH	5.5 ± 1.02	5.40	3.10	8.50

LCT= length of celiac trunk, LCH = length of common hepatic, LPH = length of proper hepatic, DCT = diameter celiac trunk, DCH = diameter of common hepatic, DPH = diameter of proper hepatic, SD= standard deviation.

Sex Differences in the Measured Dimensions

Table 2 presented the results for sex variations of the measured parameters of the study subjects. From the table, it can be observed that there was significant sex difference in all measured parameters ($p<0.05$) except the diameter of celiac trunk, with males having higher mean values in all the dimensions compared to females.

Table 2: Sex variations of the measured parameters of the study subjects (n = 93)

Variables	Sex	Mean ± SD	*t*-value	p-value
Age (years)	Male n = 48	44.13 ± 13.55	0.19	0.985
	Female n = 45	44.07 ± 15.76		
LCT (mm)	Male n = 48	19.25 ± 4.76	3.36	0.001*
	Female n = 45	15.95 ± 4.73		
LCH (mm)	Male n = 48	28.32 ± 2.73	4.61	0.000*
	Female n = 45	25.85 ± 2.41		
LPH (mm)	Male n = 48	20.24 ± 1.87	2.33	0.022*
	Female n = 45	19.31 ± 1.99		
DCT (mm)	Male n = 48	7.84 ± 1.22	1.35	0.182
	Female n = 45	7.51 ± 1.15		
DCH (mm)	Male n = 48	6.91 ± 0.92	2.24	0.027*
	Female n = 45	6.37 ± 1.37		
DPH (mm)	Male n = 48	5.70 ± 1.05	1.95	0.054
	Female n = 45	5.30±0.95		

* indicate a significant difference at $p < 0.05$. LCT= length of celiac trunk, LCH = length of common hepatic, LPH = length of proper hepatic, DCT = diameter celiac trunk, DCH = diameter of common hepatic, DPH = diameter of proper hepatic

Correlation between Dimensions of Celiac Trunk and Hepatic Arterial Dimensions of both Sexes

Table 3 shows the relationship between coeliac trunk and hepatic artery dimensions for female gender. The lengths of coeliac trunk have positive significant relationship with the length of common hepatic artery. The diameter of celiac trunk also has positive significant relationship with the diameter of proper hepatic artery while it was a negative significant relationship with the diameter of common hepatic artery.

Table 3: Pearson's co-efficient correlation of coeliac trunk and hepatic arterials in female (n = 45)

Variables	AGE	LCT	LCH	LPH	DCT	DCH	DPH
Age (years)	1	0.201	0.186	0.209	0.088	-0.153	0.257
LCT (mm)		1	0.516**	0.108	0.014	0.050	-0.069
LCH (mm)			1	0.201	-0.050	0 .061	0.140
LPH (mm)				1	0.228	-0.099	0.074
DCT (mm)					1	-0.500**	0.450**
DCH (mm)						1	-0.460**
DPH (mm)							1

**. Correlation is significant at the 0.01 level, *. Correlation is significant at the 0.05 level.

LCT= length of celiac trunk, LCH = length of common hepatic, LPH = length of proper hepatic, DCT = diameter celiac trunk, DCH = diameter of common hepatic, DPH = diameter of proper hepatic

Similarly, Table 4 shows the relationship between coeliac trunk and hepatic artery dimensions for male gender. It was observed that the lengths of coeliac trunk have positive significant relationship with the lengths of common hepatic artery as well as negative significant relationship with the diameter of coeliac trunk. The diameter of coeliac trunk was found to have positive significant relationship with the diameter of proper hepatic artery.

Table 4: Pearson's co-efficient correlation of coeliac trunk and hepatic arterials in male (n = 48)

VARIABLES	AGE	LCT	LCH	LPH	DCT	DCH	DPH
Age (years)	1	0.241	0.244	0.093	-0.106	0.213	-0.055
LCT (mm)		1	0.495**	-0.073	0.334*	0.099	-0.061
LCH (mm)			1	0.127	-0.040	0.050	-0.117
LPH (mm)				1	0.152	-0.177	-0.067
DCT (mm)					1	-0.077	0.300*
DCH (mm)						1	0.012
DPH (mm)							1

**. Correlation is significant at the 0.01 level, *. Correlation is significant at the 0.05 level.

LCT= length of celiac trunk, LCH = length of common hepatic, LPH = length of proper hepatic, DCT = diameter celiac trunk, DCH = diameter of common hepatic, DPH = diameter of proper hepatic

Table 5 shows the correlation of celiac trunk and hepatic arterial dimensions in the combined subjects. There was significant relationship between the length of celiac trunk and length of common hepatic, length of common hepatic and length of proper hepatic, length of proper hepatic and diameter celiac trunk, diameter celiac trunk and diameter of common hepatic, diameter of proper hepatic and diameter of celiac trunk. There was no significant relationship between age and all the measured dimensions.

Table 5: Correlation of celiac trunk, hepatic arterial dimensions and age of the combined subjects (n = 93)

Variables	AGE	LCT	LCH	LPH	DCT	DCH	DPH
Age (years)	1	0.174	0.193	0.151	-0.007	-0.011	0.097
LCT(mm)		1	0.572**	0.094	-0.114	0.140	0.006
LCH(mm)			1	0.244*	0.021	0.147	0.080
LPH(mm)				1	0.215*	-0.068	0 .047
DCT(mm)					1	-0.265*	0.384**
DCH(mm)						1	-0.185
DPH(mm)							1

**. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level

LCT= length of celiac trunk, LCH = length of common hepatic, LPH = length of proper hepatic, DCT = diameter celiac trunk, DCH = diameter of common hepatic, DPH = diameter of proper hepatic

DISCUSSION

This study investigated the anatomical dimensions of the celiac trunk and hepatic arteries among Hausa subjects in Kano State, Northern Nigeria. The findings provide valuable insights into the vascular anatomy of this specific ethnic group and contribute to the broader understanding of hepatic arterial variations. The study's results, including the mean lengths and diameters of the celiac trunk and hepatic arteries, as well as the observed sex-based differences.

The celiac trunk and Hepatic artery dimensions in this study align with previous studies that have documented similar anatomical metrics. For instance, the length of coeliac trunk agreed with the findings from literature [10,12,14,16] emphasizing the general consistency in these anatomical features across different populations. The mean value of length of common hepatic artery of this study was similar to the findings reported by Sebben *et al*.[11] while the mean length of proper hepatic artery disagrees with that reported by Hassan *et al*.[12]. The mean diameter of coeliac trunk obtained in this study was similar to values reported by Malnar *et al*.[10], Silveira *et al*.[14] and Yadav *et al*.[13]. The average diameter of common hepatic artery of the present study also agreed with the finding of Hassan *et al*. [12] and Silveira *et al*.[14] but was slightly higher than the findings of Petrella *et al*.[16]. Similarly, the mean diameter of proper hepatic artery of this study was slightly higher than the findings reported by Sebben *et al*.[11] and Silveira *et al*.[14].

Significant sexual variations were observed in all the parameters with the exception of diameter of celiac trunk and proper hepatic artery, with males having higher measurements in all the parameters. When compared to other studies, the mean values of both sexes in the present study were significantly higher compared to values reported by Malnar *et al.*[10] and lower than the findings of Araujo-Neto *et al*.[18]. The mean length of common hepatic artery in males was consistent with the values reported by Hassan *et al.* [12] which assessed the morphological characteristics of arterial supply to extra-hepatic biliary system of cadavers, but differed slightly from the value reported for the female gender.

For the diameter of celiac trunk in males and females, the measurements were almost similar with no statistically significant difference between the sexes and this was in consonance with findings from cadaveric measurements by Sebben *et al*.[11,] and Ishigami *et al.* [15] who conducted the measurements on liver transplant recipient; however, findings from Silveira *et al*.[14] were slightly higher than what was obtained in the present study.

The mean value of diameter of common hepatic artery in males and females were almost the same and no significant differences observed in measurements taken for both sexes, as also earlier reported [12, 14, 16], but slightly higher than the findings reported by Sebben *et al.*[11] and Ishigami *et al*.[15]. The mean value of the diameter of proper hepatic artery in males and females were also slightly higher than those earlier reported [11,15].

For correlations between dimensions, the study revealed several notable correlations between the dimensions of the celiac trunk and hepatic arteries. In females, the length of the celiac trunk showed a positive significant relationship with the length of the common hepatic artery, while the diameter of the celiac trunk was positively correlated with the diameter of the proper hepatic artery, but negatively correlated with the diameter of the common hepatic artery. These correlations suggest a complex interplay between the anatomical dimensions of these vessels. Similarly, in males, the length of the celiac trunk was positively related to the length of the common hepatic artery, but negatively related to the diameter of the celiac trunk. The diameter of the celiac trunk also positively correlated with the diameter of the proper hepatic artery. These findings were consistent with the study by Araujo-Neto *et al*.[18], who highlighted the variability in arterial dimensions and their interrelationships

Meanwhile, the study did not find a significant relationship between age and the dimensions of the celiac trunk or hepatic arteries. This lack of correlation contrasts with some literature that suggested age-related changes in vascular anatomy. For instance, Venieratos *et al*.[17] found that aging could influence arterial dimensions, potentially affecting surgical planning and outcomes. The absence of significant age-related changes in our study may be attributed to the relatively narrow age range of the participants or regional variations in vascular development.

Conclusion

This study revealed that males generally exhibit slightly higher mean values, particularly in the lengths of the celiac trunk and common hepatic artery, while the vascular diameters showed no significant sex differences. However, the length of the celiac trunk and the common hepatic artery has significant positive correlation.

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Authors' Contribution

The research manuscript was developed with the understanding that all authors made significant contributions to the study. BIJ- data collection, MHM- topic conceptualization, AAG- statistical analysis, AJN- article drafting and review.

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