MDCT Evaluation of Anatomical Variations in Celiac and Hepatic Arteries

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ABSTRACT

BACKGROUND

All vital organs in the abdomen are supplied by abdominal aorta through its major branches. Most of the individuals show normal branching pattern with few showing variations in the form of accessory arteries and replacing arteries. With the advent of laparoscopic interventions and surgeries of abdominal organs, preoperative awareness of such variations is extremely important to avoid or minimize serious vascular complications. MDCT angiography is currently, the modality of choice in detecting such variations because of its non-invasive nature and diagnostic accuracy. We wanted to evaluate and estimate the prevalence of variations of celiac artery and hepatic artery by MDCT in South Indian population.

METHODS

MDCT angiographies of 400 patients of all age groups presented with various conditions were studied in the Department of Radiodiagnosis of tertiary care center. Patients showing derangement of the target vascular area were excluded from the study. Branching pattern of celiac artery and hepatic artery was assessed by using thin sections and post processing techniques such as maximum-intensity-projection images and volume-rendered images. Variations of celiac artery were observed based on Uflacker's classification and common hepatic artery based on Michele's classification system. Collected data was entered in excel sheets and presented as descriptive statistics in the form of frequency tables.

RESULTS

Variations of celiac artery which is based on Uflacker's classification was observed in 24% of the study sample in which type V was the most common variant seen in 10.8% followed by type II in 5.8%, type III in 4.1% and type VI in 2.5%. In case of variations of common hepatic artery which is based on Michele's classification, type III was the most common variant shown by 15% of the individuals followed by type II in 10.8% and type IV in 1.6%.

CONCLUSIONS

The branching pattern of celiac and common hepatic arteries is not constant, and variations are commonly encountered in day to day practice. Identification and reporting of these variations is crucial to avoid further complications. MDCT angiography has high potential and is an easily accessible imaging technique that facilitates fast and accurate assessment of abdominal vasculature in a noninvasive manner.

KEYWORDS

MDCT Angiography, Accessory, Celiac Artery, Common Hepatic Artery, Replaced Hepatic Artery, Accessory, Variants

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BACKGROUND

Celiac axis and superior mesenteric arteries are the major branches of abdominal aorta supplying the most vital organs of abdomen through their different branches. The branching pattern of these arteries is not constant and variations are commonly encountered in day today practice. In variant patterns, vessels arise from different source or present as accessory/ replaced vessels. Accessory vessel is an additional branch to the normal artery supply. Replaced artery is the one which arises from an anomalous origin supplying the organ.[1] With the advent of laparoscopic interventions and surgeries of pancreatic and hepatobiliary system, Preoperative awareness of such variations is extremely important to avoid or minimize serious vascular complications.[2,3] The variations in the celiac axis was described by Uflacker[4] (Table 1) and Michele[5] classified the variations of common hepatic artery (Table 2). An accurate imaging of these arterial changes is of utmost important in case of hepatic resections (Table 3) and liver transplantations (Table 4).[6] MDCT angiography has an essential role in assessment of the arterial vasculature. It is one of the non-invasive, easily accessible technique with excellent diagnostic accuracy which makes it the modality of choice for the vascular evaluation. Nowadays the conventional angiography has been replaced by MDCT angiography in higher numbers leading to better analysis of the prevalence of most of the anatomical variations of the abdominal arterial system.[7,8]

The purpose of this study is to evaluate the prevalence of variations in branching and course of celiac and hepatic artery branches using MDCT angiography of abdominal aorta.

METHODS

The analysed material included 400 computed tomography angiographies (CTA) performed with a 128-detector scanner after contrast medium administration in 175 women (35%) and 325 men (65%) in the age of 18–85 years. The Study was conducted between March 2018 to August 2018, at the Department of Radio diagnosis in a tertiary care center. CT examinations were performed in emergency and elective cases for various indications. Patients of all age groups who have undergone contrast enhanced MDCT of abdomen for various indications were included. Patients with derangement of the target vascular area were excluded from the study.

MDCT Examination Protocol

All the MDCT angiographies were performed in Philips ingenuity Core 128 slice machine covering from the diaphragm to the upper thigh with following parameters.

1. Collimation- 8 × 2.5 mm
2. Table speed- 35 mm/s,
3. Slice thickness - 2.5 mm,
4. Reconstruction interval - 1.25 mm
5. Exposure factors- 120 kV, 350 mAs and 0.5 seconds rotation time.

Intravenous injection of 100 ml of nonionic contrast medium (350 mg/ml) was given at the rate of 3 ml/s and a scan was obtained after a delay of 15-20 seconds for arterial phase images followed by portal phase, venous phase and delayed phases as per required for the indication of the study. Axial images were transferred to a Philips workstation and analysed using post processing techniques.

Image Post Processing Techniques

Keeping the axial plane as basis, various post processing techniques were employed to analyse the origin and branching of arteries. The most commonly used image post processing techniques are multi planar reformation, maximum intensity projection and volume rendering technique. Analysis of celiac axis anatomy and origin of the four major arteries - the common hepatic, splenic, left gastric, and superior mesenteric arteries were done. Celiac artery variations are described according to Uflacker[4] classification system and hepatic artery variations are described based on Michele[5] classification systems. Collected data was entered in excel sheets and presented as descriptive statistics in the form of frequency tables.

Type	Presentation
Type I	Classic Celiac Trunk
Type II	Hepato-Splenic Trunk
Type III	Hepato-Gastric Trunk
Type IV	Hepato-Spleno-Mesenteric
Type V	Gastro-Splenic
Type VI	Celiac-Mesenteric
Type VII	Celiac-Colic
Type VIII	No Celiac Trunk

Table 1. Uflacker Classification of Anatomical Variations of Celiac Trunk

Type	Presentation
Type I	Normal Anatomy
Type II	LHA from LGA
Type III	RHA from SMA
Type IV	LHA from LGA and RHA from SMA
Type V	Accessory LHA from LGA
Type VI	Accessory RHA from SMA
Type VII	Accessory LHA from LGA and Accessory RHA from SMA
Type VIII	Accessory LHA from LGA and RHA from SMA.
Type IX	CHA from SMA
Type X	CHA from LGA

Table 2. Classification of Anatomical Variations of Hepatic Artery According To Michele's System

(LHA-Left hepatic artery, LGA-Left gastric artery, RHA-Right hepatic artery, SMA-Superior mesenteric artery, CHA- Common hepatic artery)

Variants Relevant in Donors	Implications of Arterial Variants for Surgery
MHA from the RHA	The hepatic plane would injury artery, compromising arterial supply to the left lobe of the liver
CHA trifurcation into the RHA, LHA, and GDA	Clamping or ligation of the CHA might cause gastric or duodenal hypoperfusion.
RHA or LHA from the CHA before origin of the GDA	Clamping or ligation of the CHA causes gastric or duodenal hypoperfusion
Variants Relevant in Recipients	
Short RHA	Increases surgical complexity and might lead to difficult anastomosis
Celiac artery occlusion	Increases the risks of graft failure and biliary Complications

Table 3. Hepatic Arterial Variants and Liver Transplantation[9]

Arterial Variants-Michel Type	Left Lobe Resection	Right Lobe Resection
Replaced LHA from the LGA (II)	Yes	No
Replaced RHA from the SMA (III)	No	Yes
Replaced RHA and LHA (IV)	Yes	No
Accessory LHA from the LGA (V)	Yes	No

Table 4. Hepatic Arterial Variants and Relevance for Tumour Resection[6]

LGA: Left gastric artery, LHA: Left hepatic artery, RHA: Right hepatic artery, SMA: Superior mesenteric artery

RESULTS

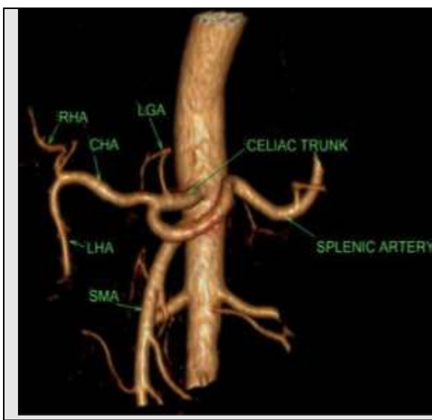
Origin	N=400	%
Variations of Origin of LGA		
Gastrosplenic trunk	43	10.8
Gastrohepatic trunk	16	4.1
Abdominal aorta	26	6.6
Variations Of Origin of Splenic Artery		
Spleno gastric trunk (Type V)	43	10.8
Spleno hepatic trunk (Type II)	23	5.8
Abdominal aorta	16	4.1
Splenomesenteric trunk	3	0.8
Variations of Origin of Common Hepatic Artery		
Hepatosplenic trunk (Type II)	23	5.8
Hepatogastric trunk (Type III)	16	4.1
Abdominal aorta	46	11.6

Table 5. The Prevalence of Anatomical Variants of Celiac Trunk

Variants	N=400	%
Normal Branching (Type I)	293	73.3
RHA from SMA (Type III)	58	15
LHA from LGA (Type II)	43	10.8
LHA from LGA and RHA from SMA (Type IV)	6	1.6

Table 6. The Prevalence of Anatomical Variants of the Common Hepatic Artery, N=400

(LHA-Left hepatic artery, LGA-Left gastric artery, RHA-Right hepatic artery, SMA-Superior mesenteric artery, CHA- Common hepatic artery



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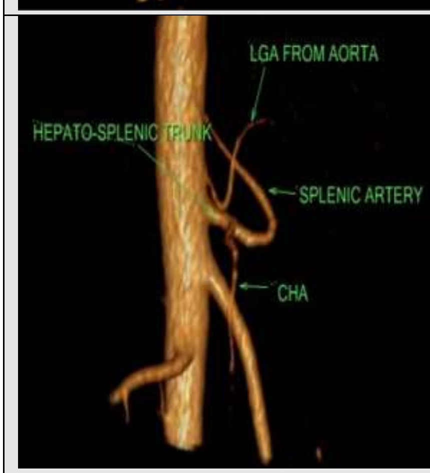

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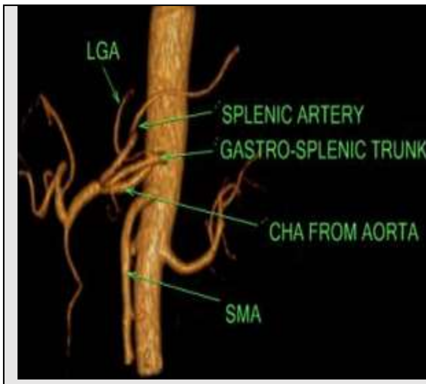

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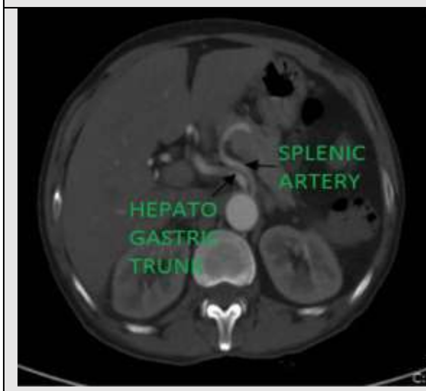

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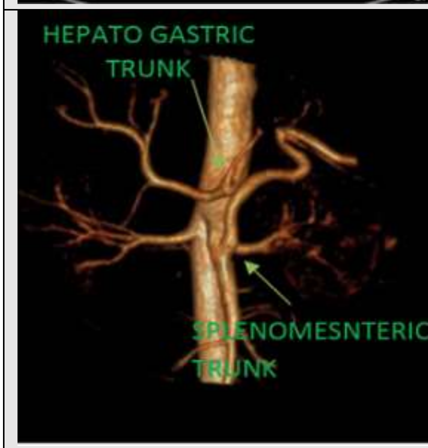

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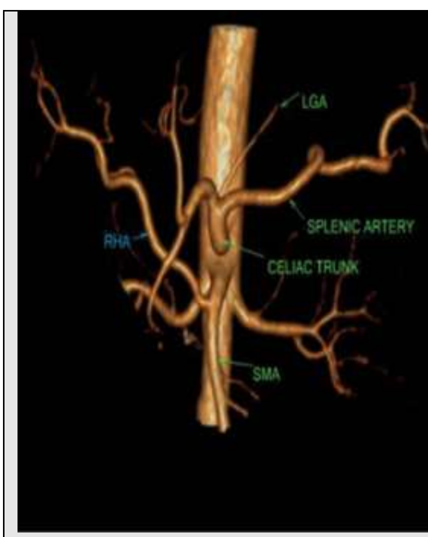
Figure 1. Volume Rendered Image Showing Uflacker Type 1 Classic Celiac Trunk Trifurcation and Michele's Type I CHA (1A), Type II Uflacker Variant (1B), Type V Uflacker Variant (1C), Type III Uflacker Variant (1D) and Unclassified Variant Spleno-mesenteric And Hepato-Gastric Trunk (1E)



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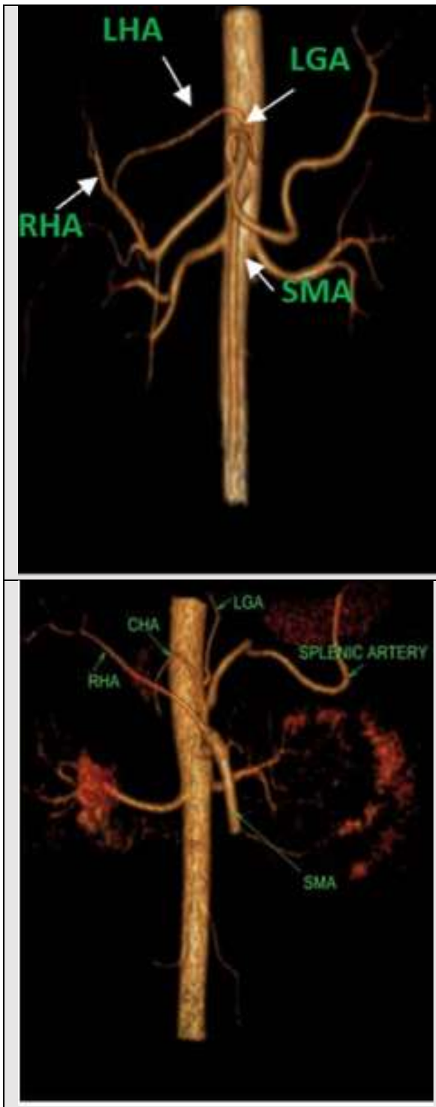

Figure 2. Volume Rendered Image Showing Type III Michele's variant (2A), Type II Michele's Variant (2B) and Type VI Michele's Variant of Common Hepatic Artery CHA with Type VIII Uflacker Variant (2C).

Celiac Artery Variations

A total of 400 patients underwent MDCT for various medical and surgical indications. Out of them 315 (78.7%) were men and 175 (43.7%) patients were women. Normal Trifurcation Pattern of celiac artery branching into left gastric, common hepatic and splenic arteries (Type I) was found in 304 patients (76%). 43 patients (10.8%) showed Gastrosplenic Trunk (Type V) where splenic artery and left gastric artery form a common branch and common hepatic artery arising separately from aorta. In 23 patients (5.8%) Hepato-splenic Trunk (Type II) was seen where common hepatic artery and splenic artery arise from a single trunk and left gastric artery having separate origin from aorta. Hepato-gastric Trunk (Type III) was shown by 16 patients (5.8%) in which common hepatic artery and left gastric artery arise from a single trunk and splenic artery having separate origin from aorta. Celiac-mesenteric (Type VI) was found in 10 patients (2.5%) with superior mesenteric artery also arising from celiac axis. No Celiac Trunk (Type VIII) i.e. branches of celiac artery arising separately from aorta was found in 3 patients (0.8%) and similarly Spleno-mesenteric and hepato-gastric trunk (Unclassified) was found in 3 patients (0.8%).

Common Hepatic Artery Branching

Normal branching pattern of common hepatic artery giving rise to right hepatic artery and left hepatic artery was noted in 293 patients forming 77.3%. The most common branching variant found was right hepatic artery arising from superior mesenteric artery (Type III) which was shown by 60 patients (15%). Left hepatic artery was seen as a branch of left gastric artery (Type II) in 43 patients (10.8%), the second most common variant. 6 patients (1.6%) showed accessory left hepatic artery arising from left gastric artery and right hepatic artery arising from superior mesenteric artery (Type IV).

DISCUSSION

The abdominal aorta begins at the hiatus of the diaphragm at the level of the T12 vertebra. The branches of aorta are classified as ventral, lateral, dorsal and terminal branches based on their anatomical orientation. Variations in the branches of these arteries occur as a result of developmental changes in the embryonic life as explained by Tandler.[10] DSA is regarded as gold standard in evaluation of vascular structures; however, it is invasive and carries a lot of risks and complications for patients.[7] In recent years MDCT has replaced the conventional angiography in analysing the vascular anatomy by allowing the radiologists to obtain images with high spatial and temporal resolution in non-invasive way and in very short period.[7,8,]

The first description of normal and aberrant celiac trunk was published by Haller in 1756.[11] The most recent classification is done by Uflacker in 1997 which classified the celiac trunk into eight types. Various studies showed different results for normal trifurcation pattern (Uflacker type I) i.e., 89% by Michel,[5] 51% by Winston et al,[12] 86% by Vandamme et al,[13] 66% by De Cecco et al,[14] 89% by Song et al,[15] and 87.6% by Yi et al.[16] In a review of literature conducted by Noussios et al.[17] in 19,013 patients, 81% showed normal trifurcation pattern. In our study 76% of patients showed normal trifurcation pattern. The most common variant of celiac axis was Uflacker type V with gastro-splenic trunk (10.8%) and least was type VIII, i.e. no celiac trunk (0.8%). Gumus et al[18] found type V to be the highest anomalies which is similar to our results but with lesser incidence. Our study showed 2.5% incidence of celiac-mesenteric trunk which is in accordance with the study of Petscavage JM et al (<3%).[19] Another unclassified ambiguous form of celiac axis was identified in 1 case of our study.

The present study showed that Michel type I is the commonest form with an incidence of 73.3% which is similar to the results of Koops et al.[20] The next commonest variant in our study was Type III, replaced RHA from the SMA representing about 15% and this is consistent with De Cecco et al[14] and Gumus et al[18] with variable incidences. However, Covey et al,[21] and Cokun et al[22] found that Michel type V was the commonest among their study population.

CONCLUSIONS

Celiac artery and hepatic artery variations are frequently noted. Preoperative awareness of such variations which includes identification of the course of the arteries and their origin is extremely important to avoid or minimize serious vascular complications. This can be achieved by MDCT angiography because of its highly robust and versatile imaging technique that facilitates fast and comprehensive evaluation of abdominal aortic vasculature in a noninvasive manner.

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