ORIGINAL ARTICLE

ANATOMICAL VARIANTS OF CELIAC TRUNK, HEPATIC AND RENAL ARTERIES IN A POPULATION OF DEVELOPING COUNTRY USING MULTIDETECTOR COMPUTED TOMOGRAPHY ANGIOGRAPHY

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Background: Multidetector Computed Tomography **(**MDCT)s has become a major part in evaluation of hepatic and renal tumours. With improvements in MDCT, CT angiography has also improved and normal anatomy and its variants in patients undergoing operative or interventional procedures can be effectively studied. The purpose of this study was to evaluate the frequency of anatomical variation of celiac trunk, hepatic and renal arterial systems in patients undergoing multidetector CT (MDCT) angiography of the abdominal aorta. **Methods:** A descriptive, retrospective cross-sectional study was carried out on CT angiographies performed during the months of October till December 2015. Hepatic and renal arteries and celiac trunk were studied and normal and anatomical variations were noted. All patients with abnormalities affecting the vessels or a history of any vascular abnormality were excluded from the study. **Results:** Out of total 110 patients, 69.1% had normal and 30.9% had variant hepatic artery with Michel Type IV being the most common variant whereas 88.2% had normal celiac trunk and 8.2% had gastrosplenic trunk variant. Variation in renal arterial system was observed in 15.5% of the patients with two renal arteries on right and two on left being the most common type. Multiple variants were identified in 11.8% of the patients. **Conclusion:** The type and knowledge of anatomy is of prime importance for an optimum preoperative planning in surgical or radiological procedure. MDCT allows minimally invasive assessment of arterial anatomy with high quality 3D reconstruction images.

Keywords: Hepatic artery variant; Renal artery variant; Celiac trunk; Variations; Multidetector Computed tomography; MDCT

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INTRODUCTION

With the advent of latest surgical advancements in liver and renal transplantation, laparoscopic procedures and minimally invasive radiological abdominal interventions, it has become significant to be aware of the normal variations in the vascular supply of these organs, in order to prevent complications during and after surgery. Variant arterial anatomy is a common finding. Michels studied hepatic arterial anatomy on cadavers described ten variant subtypes and in approximately >50% of the population.[1] Similarly Uflacker described seven variants of the normal anatomy of celiac trunk.[2] The chances of iatrogenic and unintentional vascular injury increase with aberrant and variant visceral anatomy.[3] The goal is to plan the best therapeutic approach and to have an adequate knowledge of anatomy and variations affecting a population, and this requires special attention at surgery.[4–7]

Although digital subtraction angiography (DSA) is considered the gold standard for evaluation of vascular anatomy, it has some potential drawbacks that include its invasive nature limits, patient discomfort, high cost and approximately 1% complication rate.[8] The introduction of multidetector CT scan (MDCT) has improved the CT angiography in substantial way by offering increased tissue coverage, decreased acquisition time and high spatial resolution for evaluation of arteries and its branches and decreased dose of contrast material utilized.[8] Its increasing use has made it feasible to prevent invasive DSA examination.[9] The role of CT angiography in detecting resectability of hepatic and renal tumours has been well known. An additive function of this technique is to delineate variant anatomy in patients undergoing operative or interventional procedures.[10]

The purpose of this study was to evaluate the frequency of normal and anatomical variations of celiac trunk and hepatic and renal arterial systems in patients undergoing multidetector CT angiography of the abdominal aorta for various clinical indications.

MATERIAL AND METHODS

This retrospective study was conducted at Dow Institute of Radiology, Dow University of Health Sciences after approval from the institutional review board from October till December 2015. The requirement regarding informed consent from the patients was waived as the data was collected retrospectively from the electronic medical record database. Patients who underwent CT angiogram of abdominal aorta for various reasons (Table-1) irrespective of age and gender were included in this study. Patients with allergy to intravenous contrast media, impaired renal function (serum creatinine >1.2 mg/dL), previous abdominal surgery, or any abnormality that involved the vessels were excluded. Abdominal multi-detector CT angiogram was performed using a 16-slice (Brightspeed, GE or Somatom emotion, Siemens), with slice thickness of 5 mm, at 120 kV current and automatic mA adjustment. During examination 80 ml of non-ionic contrast was injected into the patients' antecubital vein. The axial images obtained were transferred to Picture Archiving and Communication System (PACS) and workstation for analysis. Three-dimensional (3D) reconstruction was performed using 3D volume rendering technique (3D VRT). Maximum intensity projection (MIP) and multi-planar reconstruction (MPR) images of CT angiography were used for evaluation.

The anatomies of the coeliac trunk, hepatic arterial system and renal vascular structures were analysed individually and anatomical variations were noted. Anatomical variations of the coeliac trunk were described according to Uflacker's system (Table-2).[2] Anatomical variations of the hepatic arterial system were defined according to Michel's classification of that system (Table-3).[1] The existence of any artery other than a single hilar artery in each kidney was accepted as an anatomical variation. The number and origins of anatomical variations of renal arteries both unilateral and bilateral were determined in this study. Statistical package for social sciences version 21 was used for statistical analysis. Mean and standard deviation was calculated for age of the patients. Frequency and percentages was calculated for normal anatomy and anatomical variations of hepatic artery, celiac trunk, and renal artery. Comparison was done to see the relationship among hepatic, celiac and renal artery variant. Chi-square test was applied. *p*-value was taken as <0.05.

RESULTS

Out of total 110 patients, 64 (58.2%) were males and 46 (41.8%) were females. The mean age of the patients was 49.30±16.55 years. Frequency of normal anatomy and anatomical variations of hepatic artery, celiac trunk, and renal artery are shown in tables 4, 5 and 6 respectively.

Multiple variants were observed in 13 patients. The hepatic artery had the normal anatomy in 76 (69.1%) patients (Table-4). The most common hepatic artery variant in this study was replaced right and left hepatic artery (Type-IV) (7.3%), followed by replaced right hepatic artery (6.4%), and replaced left hepatic artery (6.4%) whereas type V (Figures 1-3) and type VI (Figure-4) were found in 3 (2.7%) and 4 (3.6%) respectively. Celiac trunk had normal anatomy in 97 (88.2%) patients. Gastrosplenic trunk (Figure-5) was identified as the most common variant (8.2%) followed by hepatogastric trunk (1.8%). (Table-5) Renal arteries had normal anatomy in 93 (84.5%) patients. Two renal arteries on right (Figure-6) and two renal arteries on left were identified as the most common variants (6.4%). (Table-6) Hepatosplenic trunk was observed only in 1 (0.9%) patient. Among 13 patients with celiac trunk variations, hepatic artery variation was found significantly higher in 9 (26.5%) patients as compared to 4 (5.3%) patients without hepatic artery variation (*p*-value <0.001). However, insignificant differences were observed among celiac trunk variants with renal artery variants (*p*-value 0.418) and hepatic artery variants with renal artery variants (*p*-value 0.319).

Table-1: Indications for multidetector CT angiogram

Clinical indications	Number of cases
Hepatocellular carcinoma	44
Liver abscess	23
Acute pancreatitis	17
Chronic pancreatitis	10
Liver transplant donor	7
Carcinoma of head of pancreas	4
Gall bladder carcinoma	3
Renal cell carcinoma	2

Table-2: Celiac trunk variation according to uflacker

Celiac trunk variation	Uflacker type
Classic celiac trunk	Type I
Hepatosplenic trunk	Type II
Hepatogastric trunk	Type III
Hepatosplenicmesenteric trunk	Type IV
Gastrosplenic trunk	Type V
Celiac-mesenteric trunk	Type VI
Celiac-colic trunk	Type VII
No celiac trunk	Type VIII

Table-3: Hepatic artery variants Michel classification

Hepatic artery variant	Michel type
Normal anatomy	Type I
Replaced left hepatic artery originating from left gastric artery	Type II
Replaced right hepatic artery originating from superior mesenteric artery	Type III
Co-existence of type II and III	Type IV
Accessory left hepatic artery originating from left gastric artery	Type V
Accessory right hepatic artery originating from superior mesenteric artery	Type VI
Accessory left hepatic artery originating from the left gastric artery and accessory right hepatic artery originating from the superior mesenteric artery	Type VII
Accessory left hepatic artery originating from the left gastric artery and replaced right hepatic artery originating from the superior mesenteric artery	Type VIII
Common hepatic artery originating from the superior mesenteric artery	Type IX
Right and left hepatic arteries originating from the left gastric artery	Type X

Table-4: Hepatic artery variant (n=110)

Mitchell's Type	number of cases (n)	%
I	76	69.1
II	7	6.4
III	7	6.4
IV	8	7.3
V	3	2.7
VI	4	3.6
VII	1	0.9
VIII	3	2.7
IX	1	0.9

Table-5: Celiac artery variant (n=110)

Type	number of cases (n)	%
I	97	88.2
II	1	0.9
III	2	1.8
IV	1	0.9
V	9	8.2

Table-6: Renal artery variant (n=110)

	number of cases (n)	%
Normal Anatomy	93	84.5
Two renal arteries on right	7	6.4
Two renal arteries on left	7	6.4
Three renal arteries on left	1	0.9
Two renal arteries bilateral	2	1.8

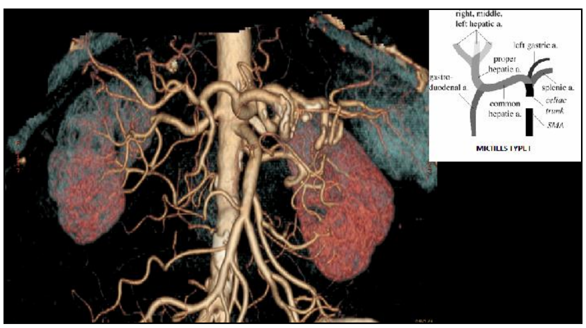

Figure-1: A 66-year old male showing normal hepatic, celiac and renal arterial system (Michels Type I, Uflacker Type I

Figure-2: A 3D reconstructed image of CT angiogram of a 46-year-old female showing accessory left hepatic artery arising from left

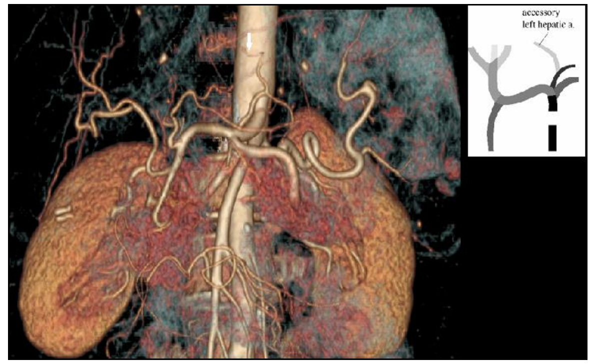

Figure-3: A 3D reconstructed image of CT angiogram of a 64-year-old female showing Michels type-V hepatic artery variant (accessory left hepatic artery arising from left gastric artery; shown by arrow)

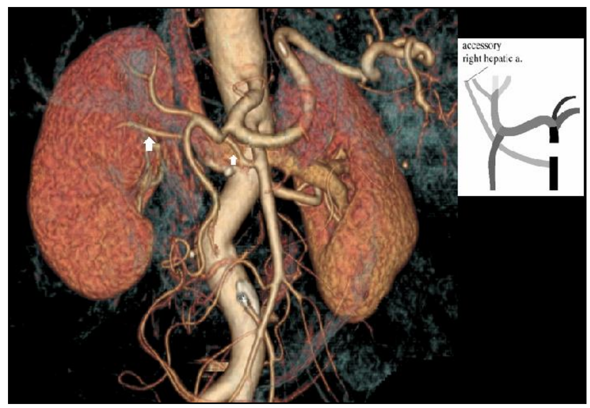

Figure-4: A 3D reconstructed image from CT angiogram of a 71-year-old female showing accessory right hepatic artery arising from superior mesenteric artery (Michels type-VI; shown by arrow)

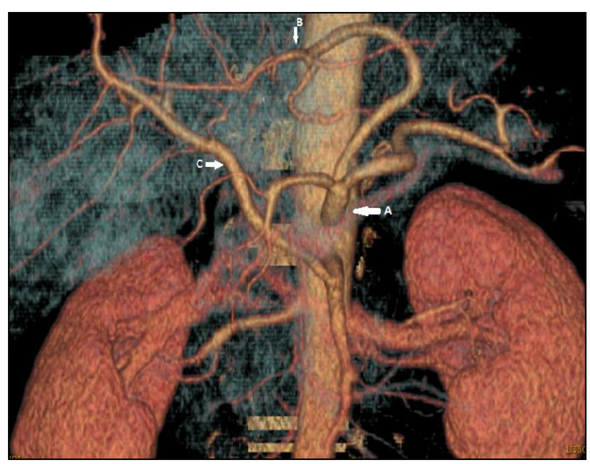

Figure-5: A 3D reconstructed image from CT angiogram of a 56-year-old male showing gastrosplenic trunk (Uflacker type-V; arrow A)

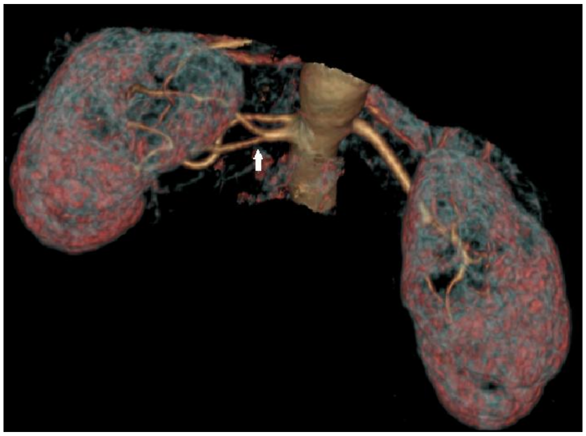

Figure-6: A 61-year-old male with two renal arteries on right side (arrow)

DISCUSSION

Michel described ten anatomical variant subtypes of hepatic arteries.[1] We used this system to describe the hepatic artery variants in this study. Michel's type I was observed in majority of the patients in this study and that corresponds to the frequency reported in previous studies.[9,11–13] The most common variant observed in this study population was replaced right and left hepatic artery (Type IV). This finding was in contrast with findings reported by other investigators in which prevalence of type IV variation was much lower.[9,14] Types II and III are the most commonly listed variations in the literature. This study's reported frequency of Type II and III was almost same as reported by other studies.[15–17]

Celiac trunk emerges from abdominal aorta immediately after the aortic hiatus, at the level of the T12 thoracic vertebra, and gives origin to the three branches, namely, the left gastric artery, which runs along the lesser curvature of the stomach; the splenic artery, which tortuously runs to the spleen; and the common hepatic artery, which extends anteriorly and bifurcates into the gastroduodenal artery, in the vascularization of the pancreas and duodenum, and the hepatic artery proper which supplies the liver.[18,19] Uflaker classified celiac artery variants into VII types[2] with normal trifurcation of celiac trunk being the most common one. Types II, III, IV, V, VI and VII described by Uflacker as Hepatosplenic trunk, Hepatogastric trunk, hepatosplenicmesenteric trunk, Gastrosplenic trunk, Celiac-mesenteric trunk and Celiac-colic trunk respectively. This study reported the normal trifurcation of celiac trunk as the most common pattern which has also been reported by previous studies.[20,21] The gastrosplenic trunk was the most common celiac trunk variant observed in this study. It was also found as a common variant in a previous study.[9] Although, literature has reported hepatosplenic trunk as the most common celiac trunk variant[18,22], this was the least common variant in this study.

Renal arteries arise from the aorta at the level of the superior margin of the second lumbar vertebral body, slightly inferior to the origin of the superior mesenteric artery. The main renal arteries divide into anterior and posterior divisions that lie anterior and posterior to the renal pelvis.[23] This study showed that in majority of the patients normal anatomy exists as reported by another study.[9] Presence of multiple renal arteries was much lower in this study as compared to the previous study[9], however studies have reported that a variation between the presence of multiple renal arteries[24–26].

Multiple variants were observed in many individuals in this study. Majority of the patients who had celiac artery variants also had variation in hepatic arterial supply. Therefore, it is recommended that if variation is identified during an angiographic examination of one viscera, then it should be kept in mind that variation of supply may exist in other visceras as well and one should look more carefully for these variations.

The invasive nature of the gold standard digital subtraction angiography for detecting vascular anatomical variations limits its use. Multi-detector CT angiography (MDCTA) has significant advantages: non-invasive examination, rapid acquisition of data, and analysis of large anatomical volumes with better image resolution. It has become a valuable tool for the visualization of normal vascular anatomy and its variants. Furthermore, reformatted three-dimensional MDCTA images allow visualization of vascular structures in angiography equivalent planes other than the axial, which is useful for evaluation of complex vascular anatomy.[22] The disadvantages include potential for contrast reactions, nephrotoxicity, and exposure to ionizing radiation.

This study had some limitations. Firstly, this was a retrospective study, so a predetermined concept may have existed that could lead to bias. Secondly, images of CT scan were analysed, so small arterial supply areas could have been missed that is beyond the scope of CT examination.

CONCLUSION

In conclusion, MDCTA provides an accurate and descriptive analysis of hepatic, celiac, and renal artery configuration. Normal and variant arterial patterns of various organs should be observed carefully because of their importance in planning treatment options and carrying out various surgical and radiological procedures.

Conflict of interest: The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTION

MA, SSNN: Conception and designing of the study. SOA, SSNN, HA: Acquisition, analysis and interpretation of data. SSNN, HA, SOA: Drafting the article & revising it critically for important intellectual content. MA, MR, MH: Final editing and approval of the manuscript.

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