Analysis of Anatomical Variations of Hepatic Arterial System and Coeliac Trunk in Multi Detector Computed Tomography

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Abstract: ***The purpose of our investigation was to determine the anatomical variations in the coeliac trunk–hepatic arterial system and the renal arteries in patients who underwent multidetector CT (MDCT) angiography of the abdominal aorta for various reasons. A total of 50 patients were analysed retrospectively. The coeliac trunk, hepatic arterial system were analysed individually and anatomical variations were recorded. Statistical analysis of the relationship between hepatocoeliac variations variations was performed using a χ^2 test. There was a coeliac trunk trifurcation in 80% and bifurcation in 8% of the cases. Coeliac trunk was absent in 2%, a hepatosplenomesenteric trunk was seen in 2% and a splenomesenteric trunk was present in 1%. Hepatic artery variation was present in 56% of patients. There was a statistically significant correlation between coeliac trunk and hepatic arterial system variations (p=0.015). MDCT angiography permits a correct and detailed evaluation of hepatic and coeliac vascular anatomy. The prevalence of variations in the coeliac trunk and/or hepatic arteries is increased in people with accessory renal arteries. For that reason, when undertaking angiographic examinations directed towards any single organ, the possibility of variations in the vascular structure of other organs should be kept in mind***.

Keywords: Coeliac, Coeliacomesenteric, Splenomesenteric, Hepatic, Aorta, Angiography

1. Introduction

Anatomical variations of the hepatic arteries and coeliac trunk are of considerable importance in liver transplants, laparoscopic surgery, radiological abdominal interventions and penetrating injuries to the abdomen [1].

The frequency of inadvertent or iatrogenic hepatic vascular injury rises in the event of aberrant anatomy and variations [2]. Arterial vascularisation of the gastrointestinal system is provided by anterior branches at three different levels of the abdominal aorta (the coeliac trunk and the superior and inferior mesenteric arteries). Differences arising during several developmental stages in the embryonal process leads to a range of variations in these vascular structures.

Digital subtraction angiography (DSA) is regarded as the gold standard in the evaluation of vascular structures, although its invasive nature significantly limits its role. In recent years, the introduction of multidetector CT (MDCT) and its ability to image vascular structures of small diameter have led to a significant reduction in the utilisation of invasive DSA examinations.

The aim of this study is to examine the anatomical variations that occur in the coeliac trunk–hepatic arterial system and renal arteries and their prevalence. We looked at these vascular systems in patients who underwent multidetector CT angiography of the abdominal aorta for various reasons.

2. Methods and Materials

2.1 Patients and imaging technique

All patients who underwent CT angiography of the abdominal aorta and its branches for various reasons in Government Medical College,Surat in June 2022 were investigated retrospectively. 50 patients were evaluated in the study (29 males and 21 females). The mean age was 48 years (age range: 10–79 years). The reasons for MDCT angiography are presented in Table 1.

Table1: Reason for multi-detector CT angiography in this series

Indication	Number of cases
Abdominal Koch's	18
Renovascular Hypertension	14
Liver Transplantation	5
Bleeding per rectum under investigation	9
Investigation of vascular invasion in pancreatic and hepatic malignancy	4
Total	50

MDCT angiography examinations were performed using a 256slice Philips brilliant iCT scanner in New Civil Hospital, Surat. The area from the lower thoracic spine to the symphysis pubis level, with the patient in a supine position, was adopted as the field of view. During examination, an 18–20gauge angiocath needle inserted into patients' antecubital vein was used to inject 120 ml of non-ionic iodinated contrast medium using the bolus tracking technique (rather than a predetermined delay time) with an automatic injector at a rate of 4 ml s^{-1}.

The axial images obtained were transferred to a workstation for analysis. Three-dimensional volume-rendering technique (3D VRT), maximum intensity projection (MIP) and multiplanar reconstruction (MPR) images were used for evaluation.

2.2 Vascular System Analysis

The raw data axial images obtained by MDCT angiography as well as the post-processed 3D VRT, MIP and MPR images were evaluated by two radiologists in consensus. The anatomies of the coeliac trunk and hepatic arterial system were analysed individually and anatomical variations recorded. Anatomical variations of the coeliac trunk were described according to Uflacker's system[3] as given in Table 2. Anatomical variations of the hepatic arterial system were defined according to Michels's [4] 1966 internationally recognised classification and Hiatt's[5] 1994 modification of that system as given in Table3.

Table 2: Coeliac trunk variations: Uflacker's classification [3]

Coeliac trunk variation	Uflacker's classification
Classic coeliac trunk	Type I
Hepatosplenic trunk	Type II
Hepatogastric trunk	Type III
Hepatosplenicmesenteric trunk	Type IV
Gastrosplenic trunk	Type V
Coeliac-mesenteric trunk	Type VI
Coeliac-colic trunk	Type VII
No coeliac trunk	Type VIII

The possibility of a correlation between coeliac trunk and/or hepatic artery variations was analysed using the χ^2 test, with p <0.05 regarded as statistically significant.

Table 3: Hepatic artery variations: Michels's and Hiatt's classifications [4, 5]

Hepatic artery variation	Michels classification	Hiatt classification
Normal anatomy	Type I	Type I
Replaced left hepatic artery originating from the left gastric artery	Type II	Type II
Replaced right hepatic artery originating from the superior mesenteric artery	Type III	Type III
Co-existence of Type II and III	Type IV	Type IV
Accessory left hepatic artery originating from the left gastric artery	Type V	Type II
Accessory right hepatic artery originating from the superior mesenteric artery	Type VI	Type III
Accessory left hepatic artery originating from the left gastric artery and accessory right hepatic artery originating from the superior mesenteric artery	Type VII	Type IV
Accessory left hepatic artery originating from the left gastric artery and replaced right hepatic artery originating from the superior mesenteric artery	Type VIII	Type IV
Common hepatic artery originating from the superior mesenteric artery	Type IX	Type V
Right and left hepatic arteries originating from the left gastric artery	Type X	NOD
Common hepatic artery directly originating from the aorta	NOD	Type VI

3. Results

Both coeliac trunk and hepatic arteries had a normal anatomy in 40 of the 50 patients (80%); either coeliac trunk or hepatic artery variation was present in the remaining patients.[Table4 and 5]. A normal coeliac trunk formed from the left gastric, splenic and common hepatic arteries was present in 89% of patients. Gastrosplenic trunk (Type V) was the most prevalent variation (8%), followed by hepatosplenic trunk (Type II) (4%). In one patient, the splenic artery and superior mesenteric artery originated from a common trunk while the common hepatic artery and left gastric artery originated from a separate common trunk. This variation has not been described by any classification, and is defined here as “splenomesenteric trunk”.

Table 4: Coeliac trunk variations found in this study

Anatomical structure	Uflacker type	Number of cases
Normal anatomy	I	40
Hepatosplenic trunk	II	2
Hepatogastric trunk	III	1
Hepatosplenomesenteric trunk	IV	1
Gastrosplenic trunk	V	4
No coeliac trunk	VIII	1
Splenomesenteric trunk	NOD	1
Total		50

The hepatic arteries had a normal anatomy (Type I) in 56% of patients. The most common hepatic artery variations in our series were replaced right hepatic artery (Type III) (12%), replaced left hepatic artery (Type II) (8%) and accessory left hepatic artery (Type V) (8%) according to Michels's classification. On the basis of Hiatt's classification, on the other hand, the most common hepatic artery variation was accessory or replaced left hepatic artery (Type II) (16%).

2 of the 50 patients in our series had unclassified hepatic artery variations. One of these was a right hepatic artery that originated from the middle colic artery and the second was a left hepatic artery originating from the common hepatic artery. Liver segment IV arteries, originating from the right hepatic artery, were determined in 21 of the 50 cases.

Table 5: Hepatic artery variations found in this study

Anatomical structure	Type	Number of cases
Normal anatomy	M-I	28
	H-I	
Replaced left hepatic artery	M-II	4
	H-II	
Replaced right hepatic artery	M-III	6
	H-III	
Replaced right and left hepatic artery	M-IV	1
	H-IV	

Accessory left hepatic artery	M-V H-II	4
Accessory right hepatic artery	M-VI H-III	1
Accessory right hepatic artery	M-VII H-IV	1
Accessory left and replaced right hepatic artery	M-VIII H-IV	1
Common hepatic artery originating from the superior mesenteric artery	M-IX H-V	2
Common hepatic artery originating from the aorta	M-NOD H-VI	1
Right hepatic artery originating from the middle colic artery	NOD	1
Left hepatic artery originating from the common hepatic artery	NOD	1
Total		50

4. Discussion

MDCT angiography allows most of the body to be scanned helically in just one breath hold, and thus providing high-contrast resolution without any artefacts. Along with axial images, 3D images provide a very good anatomical orientation. Hence, detailed information regarding vascular structures, organs and their relations with one another can be obtained.

Michels's classification of the hepatic arterial system describes 10 variant subtypes[4] based on accessory and replaced hepatic arterial systems. In Hiatt's classification, there was no such differentiation because it was angiographically difficult to distinguish between accessory and replaced hepatic arterial structures, hence six subtypes were described [5]. We used both classifications in our study. A normal hepatic arterial system has been reported in 51–80% of cases in most studies conducted using DSA [6, 7]. In our study, this ratio was about 56%. In the literature, the most frequently encountered variation is Type III, present in between 6% and 15.5% of all cases [8, 9]. The second most frequent variation, Type II, was reported in 2.5–10% of all cases [10, 11]. In our study too, Types III and II were the most commonly seen hepatic arterial variations. Types VII, VIII and X have only been reported very rarely. In our study, Types VII and VIII were determined with a rate of 2%, and no type X was encountered.

In liver transplant surgeries, the blood supply of segment IV is of utmost importance. For that reason, it is important to know the origin of its blood supply. With the fast MDCT technology, better and artefact-free images can be obtained following bolus contrast administration. In this way, hepatic arterial supply, especially the fine-calibre artery of segment IV, can be displayed very clearly. In an MDCT study conducted by Kamel et al, the segment IV artery was reported to originate from the right hepatic artery in 62.5% of cases [7]. Erbay et al [12] reported this incidence as 9% [12]. In our study, the segment IV artery originated from the right hepatic artery in 35% of cases.

Rare anomalies that are not consistent with any type described under Michels's and Hiatt's classifications can also be seen. In their study, Koops et al[11] and Abdullah et al [13] reported frequencies of 1.8% and 1.4%, respectively, for such rare and unclassified anomalies (or variations) of abdominal aortic branches. Our study revealed a frequency of 4% (in 2 of 50 patients) for these unclassified abnormalities. The existence of such unique variations shows that the embryological development of the abdominal aortic branches may be influenced by many factors and is a complex process.

Normal coeliac trunks exhibiting trifurcation have been reported with a frequency of 72–90% in the normal population [14, 15]. One of the largest series, studied by Vandamme and Bonte [16], had a frequency of 86% for normal coeliac trifurcation, which is very close to the frequency in our series (80%). Coeliac trunk bifurcation as an anatomical variation has been reported at a rate of about 12% in the literature, and was present in 8% of cases in our series. Bergman et al[14] published a meta-analysis of “no coeliac trunk reports” in the literature and calculated the average absence rate of coeliac trunk as 0.4%. In our study, coeliac trunk was absent in 1 of the 50 cases.

Splenomesenteric trunk is a very rare variation with an occurrence rate of below 1% [17]. Oran et al [18] have reported a case in which the splenic artery formed a common trunk with the superior mesenteric artery, and the common hepatic artery formed a separate trunk with the left gastric artery [18]. Similarly, two separate trunks, a splenomesenteric trunk and a hepatogastric trunk, not described under any classification, were present in one patient in our study.

In our study, there was no anatomical variation pertaining to a common origin of the visceral artery branches and the lateral branches of the aorta. The embryological development of the kidneys and the visceral organs or intestines are regarded as different and independent of each other. However, anomalies in the migration of both the liver and the kidneys can occasionally establish a link between the visceral branches of the aorta and lateral branches. Examination of the literature shows that no such correlation has to date been reported. The results in our study, however, clearly show that there is an association between these two independent vascular variations. We consider that further investigation of this relationship with studies comprising larger populations would be useful.

In conclusion, MDCT angiography permits an accurate and detailed analysis of hepatic vascular anatomy. Angiographic information required to determine treatment options and to prevent complications arising from vascular variations during surgery or intervention can easily be obtained using MDCT. The likelihood of coeliac trunk and/or hepatic arterial variation rises in those individuals with more than one renal artery. Therefore, if variations are discovered during the angiographic examination of one organ, it must be kept in mind that there may be variations in the vascular structures of the other organs, and a more detailed investigation must be performed.

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Author Profile

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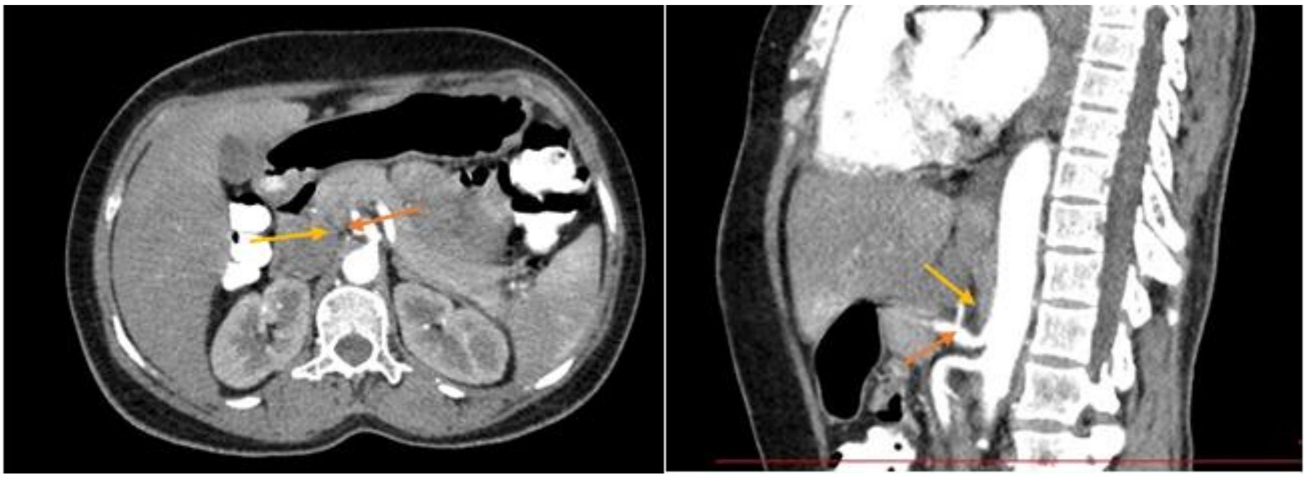
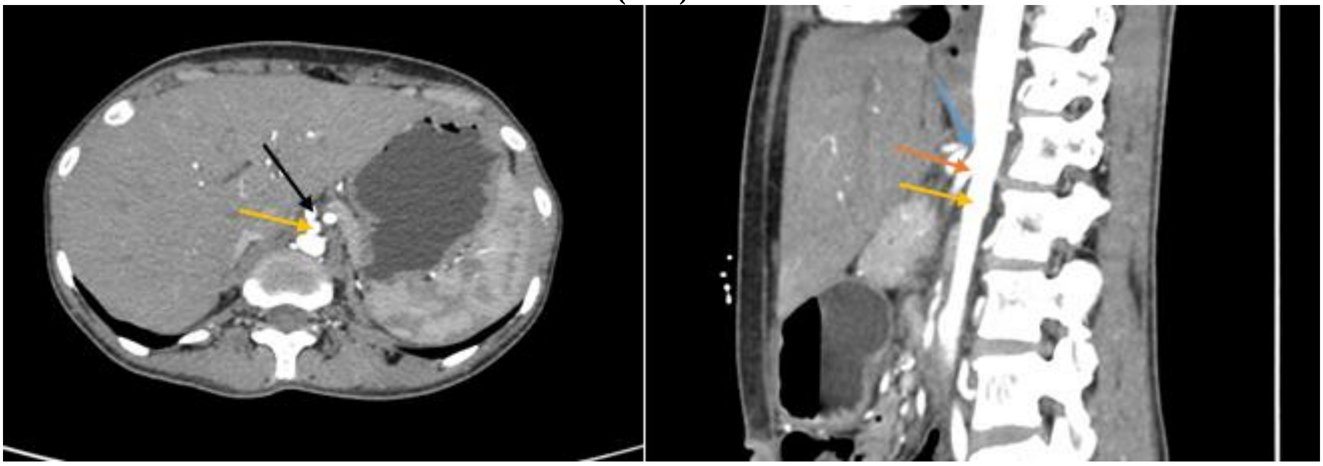


A **B**

(A) Axial post-contrast CT Angiography image and (B) Sagittal post-contrast CT Angiography image showing origin of right hepatic artery (yellow arrow) directly from the coeliac trunk(orange arrow).



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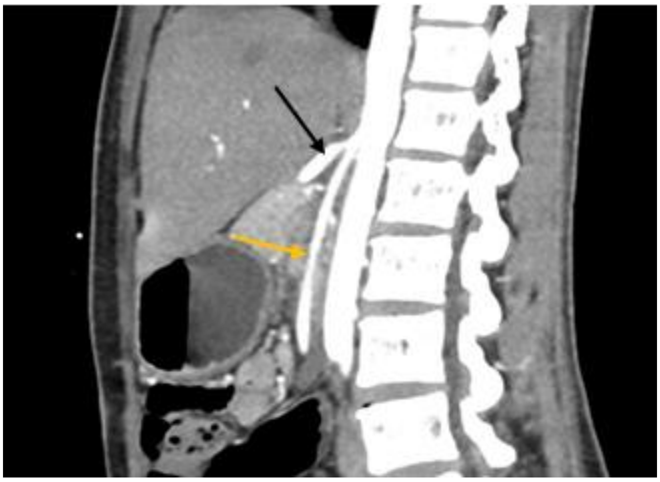

C

(A) Axial post-contrast CT Angiography image, (B) and (C) Sagittal post-contrast CT Angiography images showing origin of common hepatic artery(green) and superior mesenteric artery(yellow) as a common trunk from abdominal aorta, left gastric artery(blue) and splenic artery(orange) as a common trunk directly from abdominal aorta.