Research Article

Spectrum of coeliac trunk, hepatic artery and renal artery variations - analysis by multi detector computed tomography

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Abstract

Context: The anatomy and variations of abdominal aortic branches needs to be established at pre operative imaging to avoid/ minimize the ischemic complications that could occur during surgeries such as liver transplants, laparoscopic surgery, vascular interventions etc. **Aims:** To determine the comprehensive spectrum of celiac axis, hepatic and renal artery variations with the use of multi-detector computed tomography (MDCT). **Methods and Material:** CT images of 200 patients who underwent MDCT abdomen in our hospital for various indications between June to September 2013 were analyzed retrospectively. The celiac trunk, hepatic and renal arterial system were individually assessed and variations noted. **Statistical analysis used:** The possibility of an association between celiac-hepatic arterial variations and renal artery variations were assessed using chi-square test with $p < 0.05$ as statistically significant. **Results:** There was normal trifurcation of celiac trunk in 95% patients, hepatosplenic trunk and gastrosplenic trunk (celiac bifurcation) in 2.5%, and quadfurcation in 1%. Hepatic artery variations were present in 67 patients (33.5%) and renal artery variations in 76 patients (38%). Celiac trunk and/ or hepatic artery variations were present in 38 of 124 patients (30.6%) with no renal artery variation and in 36 of 76 patients (47.3%) with renal artery variations. There was a statistically significant correlation noted between renal artery variations and coeliac trunk–hepatic arterial system variations (p= 0.026 by chi square test). **Conclusions:** Variations in the celiac trunk, hepatic artery and renal artery are common and their detection is important prior to any interventions or abdominal surgeries. MDCT allows rapid, accurate non-invasive evaluation of these variations.

Keywords: MDCT, celiac trunk, hepatic arteries, renal arteries, variations, pre-operative imaging.

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INTRODUCTION

At pre operative imaging of upper abdomen it is essential to establish the anatomy and variations of the upper abdominal arterial system [celiac trunk, hepatic arterial system and renal arteries] to avoid/ minimize the ischemic complications that could occur in the organs at surgery[1]. These anatomical variations of the hepatic arteries and celiac trunk are of considerable importance in liver transplants, laparoscopic surgery, radiological abdominal interventions and surgical treatment of penetrating injuries to the abdomen[2,3]. The identification of renal artery variations is important in renal transplantation surgeries, surgical or interventional radiological treatment of reno-vascular hypertension and nephrectomy[4]. For deciding the best therapeutic approach, reduction of complications, and identification of anatomy requiring special attention at surgery, diagnostic imaging with multi-detector computed tomography (MDCT) imaging is necessary as it allows quick, accurate and non-invasive preoperative evaluation of the upper abdominal arterial anatomy and is comparable to digital subtraction angiography (DSA) which is invasive[5]. The purpose of this study was to determine the prevalence and comprehensive spectrum of

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celiac axis and hepatic artery and renal artery variations with use of MDCT; to assess the known variations and describe any newly found ones; and to look for any association between renal and celiac-hepatic artery variations.

SUBJECT AND METHODS

This was a retrospective analysis study. A total of 200 patients who underwent MDCT of the abdomen at our institution for various indications between June 2013 to September 2013 were included in the study. Patients of all ages and both sexes who underwent MDCT of the abdomen were included. All patients with a history of prior major upper abdominal surgery and patients with occlusion of celiac, hepatic, renal arteries were excluded. All scans were done using GE Bright speed 16 –slice MDCT at 120 KVp and 300 mAs with 5mm slice thickness, 0.8 second gantry rotation. Arterial phase images were retro reconstructed with 0.625 mm slice thickness and reformatted in sagittal and coronal planes and maximum intensity projection (MIP) images for analysis. Each arterial system was individually assessed and recorded using Uflacker's classification system for celiac artery and Michels's classification along with Hiatt's modification for hepatic arteries[5]. The renal arteries were assessed with respect to their origin, number of arteries and laterality.

RESULTS

A total of 200 patients' MDCT images were retrospectively evaluated. The mean age of patients was 52 years (6-86 years); 102 were males and 98 were females. There were a total of 77 (38.5%) different variations involving the celiac and hepatic arteries out of total 200 patients. 190 patients (95%) showed a normal formation and division (type I) i.e. trifurcation of celiac artery into common hepatic, left gastric and splenic arteries. Three patients showed a common hepatosplenic trunk (type II) and two showed a common gastrosplenic trunk (type V) (Fig 1) according to Uflacker's classification [Table 1]. Two patients had quadfurcation with absent common hepatic artery and branching into right hepatic, left hepatic, left gastric and splenic arteries (Fig 2 a,b). In these cases, the gastroduodenal artery was noted to arise from left hepatic artery. In one particular patient, the common hepatic artery arose from the superior mesenteric artery (SMA) and the left gastric, splenic arteries had their origins separately from the aorta (Fig 3 a,b,c). Total of 133 patients (66.5%) had a normal hepatic arterial system. The most common variation was that of replaced left hepatic artery from left gastric artery (type II) in 22 patients (11%); followed by accessory left hepatic artery (type V) in 18 patients (9%) according to Michels's classification [Table 2]. In two patients, the right hepatic artery was noted to arise from the aorta directly, with absent common hepatic artery and the other branches of celiac artery arising together (Fig 4 a,b). One case of replaced left hepatic artery from left gastric artery along with accessory right hepatic artery from SMA was observed and these cases were unclassified in the standard classification systems used (Fig 5). Renal artery evaluation showed normal anatomy with bilateral individual renal arteries in 124 patients (62%) and more than one renal artery in 76 patients (38%). The commonest variation was noted to be two renal arteries on the left side in 29 patients (14.5%) [Table3]. The accessory arteries always originated from abdominal aorta and most commonly supplied the lower pole. There was an incidence of solitary right pelvic kidney but without any significant variation. 38 of the 124 patients (30.6%) with no renal artery variation had celiac-hepatic arteries variations, whereas 36 of the 76 patients (47.3%) with renal artery variation also had coeliac trunk and/or hepatic artery variation. The association between coeliac trunk and/or hepatic artery variations and renal artery variations was significant (chi-square test, p= 0.026).

Table 1: Spectrum of variations in the celiac trunk

Celiac trunk variation	Uflacker's classification[5]	Number of cases in our study
Classical celiac trunk trifurcation	TYPE I	190
Hepato-splenic trunk	TYPE II	3
Hepato-gastric trunk	TYPE III	0
Hepato-splenic mesenteric trunk	TYPE IV	0
Gastro-splenic trunk	TYPE V	2
Celiac- mesenteric trunk	TYPE VI	0
Celiac- colic trunk	TYPE VII	0
No celiac trunk	TYPE VIII	0
Coeliac trunk Quadfurcation		2
Left gastric and splenic artery with separate origins and common hepatic from superior mesenteric artery		1
Right hepatic artery arising from aorta and other branches of coeliac artery together		2
	Total	**200**

Table 2: Spectrum of variations in the hepatic artery

Hepatic artery variation	Michels's[5]	Hiatt's[5]	No. Of cases in our study
Normal anatomy	TYPE I	TYPE I	133
Replaced left hepatic artery originating from the left gastric artery	TYPE II	TYPE II	22
Replaced right hepatic artery originating from the superior mesenteric artery	TYPE III	TYPE III	11
Co-existence of Type II and III	TYPE IV	TYPE IV	07
Accessory left hepatic artery originating from the left gastric artery	TYPE V	TYPE II	18
Accessory right hepatic artery originating from the superior mesenteric artery	TYPE VI	TYPE III	07
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	01
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	0
Common hepatic artery originating from the superior mesenteric artery	TYPE IX	TYPE V	0
Right and left hepatic arteries originating from the left gastric artery	TYPE X	NOD	0
Common hepatic artery directly originating from the aorta	NOD	TYPE VI	0
Replaced left hepatic artery from left gastric along with accessory right hepatic artery from superior mesenteric artery			1
NOD= not otherwise described in literature	**Total**		**200**

Table 3: Spectrum of variations in the renal artery

Renal artery variation	Types[5]	No. of cases in our study
Normal anatomy	I	124
Two renal arteries on the right	II	23
Two renal arteries on the left	III	29
Three renal arteries on the left	IV	01
Two renal arteries on each side	V	21
Two renal arteries on the right and three renal arteries on the left	VI	0
Three renal arteries on the right side	VII	02
	Total	**200**

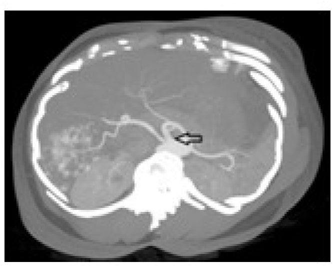

Figure 1: Maximum intensity projection (MIP) oblique axial arterial phase image - Type 5 coeliac artery division showing a common gastrosplenic trunk (black thick arrow) and separate origin of common hepatic artery

Figure 2a: Contrast enhanced CT of the abdomen arterial phase image showing quadfurcation of coeliac trunk into right hepatic, left hepatic, left gastric and splenic arteries.

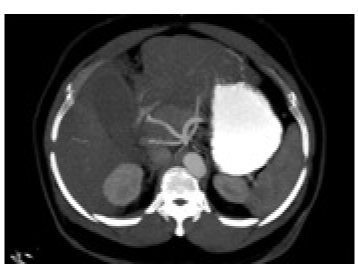

Figure 2b: Maximum intensity projection (MIP) image showing Quadfurcation of coeliac trunk into right hepatic, left hepatic, left gastric and splenic arteries

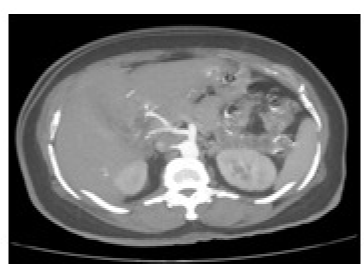

Figure 3a: Contrast enhanced CT of the abdomen arterial phase axial section Maximum intensity projection (MIP) images showing origin of common hepatic artery from superior mesenteric artery

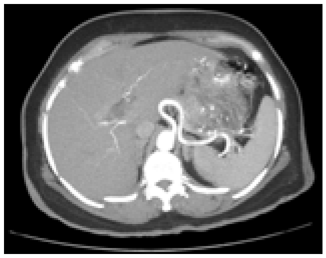

Figure 3b: Contrast enhanced CT of the abdomen arterial phase axial section Maximum intensity projection (MIP) images showing origin of splenic artery from aorta

Figure 3c: Sagittal reformatted image of the arterial phase showing separate origin of left gastric (plain arrow) and splenic artery (white arrow) from the aorta; and superior mesenteric artery giving rise to common hepatic artery (black arrow)

Figure 4a: Contrast enhanced CT of the abdomen arterial phase MIP image (axial view) showing absent common hepatic artery and direct origin of right hepatic artery from aorta. The left hepatic branch, left gastric and splenic artery have a common origin

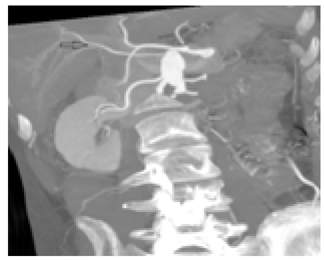

Figure 4b: Contrast enhanced CT of the abdomen arterial phase MIP image (oblique coronal) showing absent common hepatic artery and direct origin of right hepatic artery (plain arrow) from aorta. The left hepatic branch, left gastric and splenic artery have a common origin

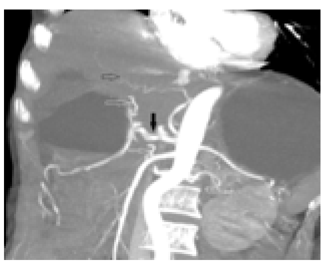

Figure 5: Coronal reformatted MIP image of arterial phase CT showing combination of replaced left hepatic artery (black plain arrow) arising from left gastric artery; and an accessory right hepatic artery (white arrows) from superior mesenteric artery. The native hepatic artery is indicated by the bold black arrow

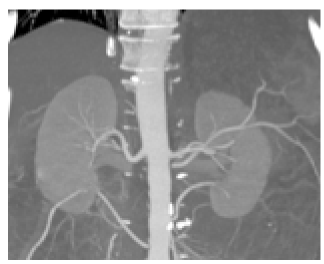

Figure 6: Bilateral accessory renal arteries as seen in coronal reformatted MIP images of arterial phase

DISCUSSION

In the evaluation of the abdominal arteries, DSA is regarded as the gold standard, but there are certain drawbacks such as invasive nature and inability to diagnose certain variations due to variability in the technique, origin and small size of the arteries. MDCT angiography provides detailed high contrast resolution images, and is a non-invasive procedure. Arterial phase images, along with 3D reformation and MIP images provide excellent anatomical detail of the arteries. The main pitfall in our study using MDCT was difficulty in interpretation of MIP images in cases of tortuous and thin caliber arteries. The hepatic arterial system classification according to Michels's system described ten types and in Hiatt's system showed six types (due to difficulty in angiograms to differentiate replaced and accessory arteries). The most common type of variation in our study was type II (11%) followed by type V (9%), where as in literature the commonest was type III followed by type II (2.5-10% of cases)[6,7]. Normal hepatic arterial system was reported in 51-80% in majority of studies using DSA[8]. In our study, normal pattern was seen in 66.5%. Types VII, VIII, IX, X were rarely encountered in literature and our study showed one type VII variation and one unclassified variation (replaced left hepatic artery from left gastric along with accessory right hepatic artery from SMA) which was not reported in Michels's and Hiatt's classification. Celiac trunk trifurcation (normal anatomy) was seen in 72-90% cases in normal population whereas 95% of our cases showed normal anatomy and 5% showed variations, which is comparable with 4.5% according to Kornafel *et al*[9]. Celiac trunk bifurcation was seen in 2.5% as opposed to 8% seen in Ugurel *et al*[5]. 1% of cases showed quadfurcation of celiac artery. A single patient had separate origins of left gastric, splenic arteries with common hepatic arising from SMA which is a rare variation seen in 0.24% of patients in the study by Song *et al*[1]. This variation needs to be noted specially in pre operative evaluation for pancreaticoduodenectomy[10]. The wide variety of variations in renal arteries is a result of their changing blood supply due to progressive ascent from the pelvis[4,9]. Accessory arteries can cross and compress important structures, an example being lower pole artery compressing the ureter and they need to be assessed pre operatively or before renal interventions. There was an incidence of 38% of accessory arteries in our study as compared to a wide variety of variations 9-76% in literature. Accessory renal arteries were more common on the left side 29 patients (14.5%) as compared to 23 patients (11.5%) on the right side. 21 patients (10.5%) showed accessory arteries bilaterally (Fig 6), which is in agreement with the study of Kornafel *et al*[9]. The presence of variations on the left side is of importance due to preference of harvesting left kidney laparoscopically for renal transplantation[9]. The post surgical rates of kidney loss and complications are lower in transplanted kidneys with single renal artery as compared to those with multiple arteries[4,11]. MDCT scores over angiography in detection of accessory renal arteries especially when they are thin as they are either not visible or confused with adrenal or capsular arteries when they enter the parenchyma directly[4]. Celiac trunk and/ or hepatic artery variation was present in 38 of 124 patients (30.6%) with no renal artery variation and in 36 of 76 patients (47.3%) with renal artery variations and denotes a statistically significant correlation between hepatic-celiac and renal artery variations (chi-square test, $p = 0.026$). Such similar association has been reported previously reported in the study done by Ugurel *et al*[5]. Thus our study also indicates that there may be a common factor associated in causing variations in two unrelated arterial systems during embryogenesis.

LIMITATIONS

The total number of patients included in the study was relatively small. Hence some of the rare variations in celiac/ hepatic artery were not observed in the study. A larger study over a longer period of time would be recommended.

CONCLUSION

Variations of celiac, hepatic and renal arteries are common and can be accurately assessed using MDCT. There is also a significant association between renal artery variations and celiac/hepatic artery variations.

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