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Anatomic variation of celiac axis and hepatic artery as evidenced in multidetector computed tomography in patients at tertiary care center in Nepal

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Abstract

Introduction: There are many potential anatomic configurations of celiac axis and hepatic artery. Michel's classified hepatic arterial variations in 10 categories. Knowledge about these variations in patient is invaluable before surgery. Multidetector computed tomography (MDCT) can accurately depict the vascular anatomy of celiac axis and hepatic artery non-invasively. The aim of this study was to find out the prevalence of different types of anatomical variation of celiac axis and hepatic artery in patients undergoing multiphase CT.

Method: Cross-sectional, prospective study was done in Department of Radiology, Patan Hospital, Patan Academy of Health Sciences. MDCT of abdomen of 178 patients with arterial phase images done between December 2021 and March 2022 were evaluated for arterial anatomy of celiac axis and hepatic artery. Arterial anatomy was categorized according to Michel's classification. Prevalence of each variant anatomy and gender wise prevalence were calculated.

Results: CT scans of 178 patients were evaluated out of which 94 were male and 84 were female. Among these individuals 133 (74.7%) had normal anatomy (Type I) and 45 (25.3%) had some sort of variant anatomy. Type III was commonest type of variant anatomy seen in 18 (10.1%) individuals. We found 6(3.4%) individuals with the anatomy other than classified by Michel.

Conclusion: There are multiple variation in of celiac axis and hepatic artery anatomy in our population. Knowledge of such anatomical variation will be of great importance for surgeon and interventional radiologist for planning of surgical or vascular procedures and to prevent vascular complication.

Keywords: anatomy, celiac axis, hepatic artery, multidetector computed tomography, variation

Introduction

The celiac axis and its branches are critically important arteries that supply blood to the vital solid and hollow abdominal viscera of the foregut. There are many potential anatomic configurations of celiac axis and hepatic artery.[1] According to normal anatomy, the celiac trunk originates from aorta and gives rise to the common hepatic artery(CHA), the left gastric artery(LGA), and the splenic artery(SA). The CHA gives rise to the gastroduodenal(GDA) and the proper hepatic(PHA) artery. The latter in turn gives rise to the right hepatic artery(RHA), the left hepatic artery(LHA). In 1966 Michel classified hepatic arterial variations in 10 categories, based on a cadaveric study. He showed that the normal anatomy was seen in 55% of cases only.[2] Anatomical variations of the celiac trunk may be decisive when planning surgical or radiological upper abdominal procedures.[3] With the advent of newer interventional and surgical options for patients with primary and metastatic hepatic malignancies, partial hepatectomy for liver transplantation and laparoscopic cholecystectomy, surgeons and interventional radiologists are now relying on accurate imaging and assessment of the hepatic arterial supply.[4] Preoperative knowledge of variant arterial anatomy may reduce extensive exploration during surgery and consequently decrease the risk of vascular damage.[5] Multiple studies have been carried out in past has shown different prevalence of normal anatomy of celiac axis and hepatic artery ranging from 55% to 87%.[6, 7]The aim of this study was to find out prevalence of different types of anatomical variation of celiac axis and hepatic artery and find out gender specific prevalence of different variants.

Method

This was a prospective cross-sectional study done in Department of Radiology and Imaging of Patan Hospital, Patan Academy of Health Sciences (PAHS), Lagankhel. Study was conducted after ethical clearance of the institutional review committee (IRC) of PAHS (Ref: drs2111261581). Computed tomography (CT) scan of 178 patients who underwent multiphase CT scan of abdomen between period of December 2021 to March 2022 were evaluated. CT scans of patients with previous history of hepatic, pancreatico-biliary surgery and suspected vascular diseases and CT scans with suboptimal arterial phase were excluded from study.

CT protocol: All MDCT for this study were done in Philips Ingenuity 128 slice CT scanner. CT scan parameters used were 120kVP, 230mAs with slice thickness of 1.25mm and pitch of 0.891. Non-contrast CT was obtained from dome of diaphragm to symphysis pubis. ROI was placed in descending thoracic aorta with threshold of +150HU. Iodinated intravenous contrast media at dose of 1mg/kg was injected with help of power injector at 3-5ml/sec followed by saline chase. Auto triggering of scan with 5 second delay upon reaching threshold value to obtain arterial phase images.

Image analysis: All arterial phase images were examined by radiologist with multiplanar reformation (MPR), maximum intensity projection (MIP) and volume rendering (VR) in a workstation with Philips Intelli Space Portal software. MPR and MIP were primarily used for evaluation of celiac axis and hepatic arteries. VR technique was used for generation of 3 dimensional (3D) volumetric images for confirmation of MPR and MIP findings.

Type of celiac artery and hepatic artery anatomy was recorded as different types as described in Michel's classification as shown in table 1. Arterial variant anatomy that did not matched with types described by Michel were grouped as "others". Prevalence of different variant anatomy and gender wise distribution was calculated with SPSS 16 software.

Result

CT scans of 178 patients were evaluated. Among these 94 CT were of male and 84 were of female patients. Among these 178 patients, 133 (74.7%) patients had normal (type I) anatomy of celiac and hepatic artery and 45 (25.3%) patients had some kind of variant anatomy. Among these 25(26.6%) male patients and 20(23.8%) female patient) had variant anatomy.

Type II anatomy (replaced LHA from LGA) was present in 5 (2.8%) patient among which 4 patients were male and 1 was female. Replaced RHA from SMA (Type III) anatomy was the commonest variant anatomy seen in this study. Total of 18(10.1%) patient had this anatomy with 10 seen in female and 8 seen in male patients. Type IV anatomy (replaced RHA from SMA and replaced LHA from LGA) was seen in 3 (1.7%) patients. All patient with type IV anatomy were male. Type V anatomy (accessory LHA from LGA) was seen in 6 (3.4%) patients out of which 2 were female and 4 were male patients. Type VI anatomy (Accessory RHA from SMA) was seen in 1(1.2%) female patient only. Type VIII anatomy (accessory LHA from LGA and replaced RHA from SMA) was seen in 3 (1.7%) patients; 2 females and 1 male patient. Type IX anatomy (CHA from SMA) was seen in 3 (1.7%) patients of which all were male.

Not a single case of type VII (accessory RHA from SMA and accessory LHA from LGA) and type X variant anatomy (CHA from LGA) was recorded in this study. Whereas total 6 (3.4%) patients (4 females and 2 male) had anatomic variations other than that included in Michel's classification. Among them 2 patients had direct origin of common hepatic artery from aorta. 1 had replaced right hepatic artery from pancreaticoduodenal artery, 1 with accessory RHA from SMA and LHA from LGA, 1 had common celiaco-mesenteric trunk and 1 with LHA originating directly from aorta.

Table 1. Michel's classification[26]

Type	Description
I	Normal anatomy
II	Replaced Left Hepatic Artery (LHA) from Left Gastric artery (LGA)
III	Replaced Right Hepatic Artery (RHA) from Superior Mesenteric Artery (SMA)
IV	LHA from LGA and RHA from SMA
V	Accessory LHA from LGA
VI	Accessory RHA from SMA
VII	Accessory LHA from LGA and Accessory RHA from SMA
VIII	Accessory LHA from LGA and RHA from SMA
IX	Common Hepatic artery (CHA) from SMA
X	CHA from LGA

Table 2. Distribution of different anatomical variants in study population.

Mitchel classification	Male	Female	total
I	69 (73.4%)	64 (76.2%)	133 (74.7%)
II	4 (4.3%)	1(1.2%)	5(2.8%)
III	8 (8.5%)	10(11.9%)	18(10.1%)
IV	3 (3.2%)	0	3(1.7%)
V	4 (4.3%)	2(2.4%)	6(3.4%)
VI	0	1(1.2%)	1(0.6%)
VII	0	0	0
VIII	1 (1.1%)	2(2.4%)	3(1.7%)
IX	3 (3.2%)	0	3(1.7%)
X	0	0	0
Others	2 (2.1%)	4(4.8%)	6(3.4%)
Total	94	84	178

Discussion

The variations in the hepatic arterial system are very common which were found in the present study. Hepatic artery and its branches showed several variations and has been well documented. Anatomical variations of the celiac artery are reported in the range of 10%-49%, which occur during embryological differentiation in fetal life.[8]

During human embryogenesis, four roots of omphalomesenteric artery arise from abdominal aorta and are interconnected by a ventral longitudinal anastomosis. Two central roots of these four aortic branches disappear during embryogenesis and the first and fourth root connects to each other with longitudinal anastomosis. The splenic, left gastric, and CHA will come from this longitudinal anastomosis and the SMA from the fourth roots of omphalomesenteric artery. Remain or regression of any of these arteries leads to the development of vascular variations of the celiac trunk or SMA. [9]

Accurate preoperative assessment of the hepatic vascular and biliary anatomy is essential to ensure safe and successful hepatic surgery. Such surgical procedures range from the more complex, like tumor resection and partial hepatectomy for living donor liver transplantation, to others performed more routinely, like laparoscopic cholecystectomy.[10] The frequency of inadvertent or iatrogenic hepatic vascular injury rises in the event of aberrant anatomy and variations.[11] In liver transplant surgeries variations of the anatomy of donor hepatic arteries increase the number of arterial anastomoses during liver transplantation and, possibly, the incidence of hepatic artery thrombosis.[12]

Rapid volumetric acquisition of thin-slice high resolution images of the abdominal arteries during the phase of maximal contrast enhancement with the help of MDCT allows 3D reconstructions to be created, providing the radiologist and the surgeon with a 3D model of the patient's arterial anatomy. MDCT angiography has a reported accuracy of 97–98% compared with conventional angiography for detecting arterial variants. [13]

Anatomical variations of the celiac trunk may be decisive when planning surgical or radiological upper abdominal procedures. Identification of celiac trunk variations may avoid vascular complications during procedures such as liver transplantation and others like transcatheter arterial chemoembolization, where the lack of recognition can lead to non-target embolization.[3]The presence of celiac trunk or hepatic arterial anomaly influences preservation of vascular arterial system and achievement of an R0 resection in the liver and pancreatic resection.[14]

Various cadaveric and radiological based studies done on different populations has shown different prevalence rates of anatomy of celiac and hepatic artery.

A study done by Mansur DI et al in Nepalese sample population of 104 patients at Dhulikhel hospital showed prevalence of normal (type I) anatomy in 86.5% and variant anatomy in 13.5%. Type IX variant (CHA from SMA) anatomy was the most commonest variant anatomy(3.9%) in their study.[6] However in our study the prevalence of variant anatomy was found to be higher (25.3%) and type III variant anatomy (replaced RHA from SMA) was the commonest variant anatomy (10.1%).

The two most widely accepted classifications of hepatic arterial variations are those by Michels[15], based on 200 autopsies, and Hiatt[16], based on 1000 donor livers. In both series, type III (replaced RHA from SMA) was the most commonly reported vascular variation.[15, 16]

A retrospective study done by Krisdee Prabhasavat, et al. by studying MDCT of 200 patients showed hepatic arterial anatomic variation in about 16% of population. Type III was most common variation in their study and prevalence of other uncategorized variations were 2.5%.[17]Another MDCT based study done among 400 patients by Vijayakumar K.R. et al showed variant anatomy in 24% of study population with type III being commonest variant.[18] Result of our study is comparable with these studies.

In Type III variant the replaced RHA originating from the superior mesenteric artery has usually abnormal course. This abnormal course of right hepatic artery has significant practical implications for practicing surgeons and interventional radiologists. Replaced RHA usually has a close relationship with the head of the pancreas, rendering it vulnerable to damage during pancreatic head resections. It is crucial to recognize a replaced RHA from SMA during pancreatico- duodenectomy in order to avoid inadvertent injury.[19, 20] Similarly, aberrant RHA often runs in a low and twisted manner close to the cystic duct and gallbladder. In such case laparoscopic cholecystectomy there is not only a risk of hepatic infarction due to accidental ligation or clipping, but also a risk of bleeding complications.[21]

In another study done in 150 living liver donors by MDCT, Keles, et al. found variant hepatic anatomy in 36.6%. Type II variation (replaced LHA from LGA) was seen in 6.6%.[22] This anatomy was seen in 10% in study by Mitchel[15] and 2.5% in study by Koops[21]. In our study population prevalence of this study was only 2.8%. Left gastric artery is ligated during gastric cancer surgery and embolization of left gastric artery is done for upper gastrointestinal bleeding. Failure to identify replaced LHA from LGA before these procedures could cause significant hepatic complications and morbidity.[23, 24]

Type IV (LHA from LGA and RHA from SMA) type VII (Accessory LHA from LGA and Accessory RHA from SMA) and type X (CHA from LGA) are relatively rarer anatomical variants as their prevalence were 1%, 1% and 0.5% in the study by Mitchel.[15]In our study also we could not find a single case with type VII and type X variation. Other studies done by Keles, et al. and Duran, et al., also showed rarity of these two variants, as they did not detect these variants in their study as well.[22,25]

In our study type IV (LHA from LGA and RHA from SMA), VIII (Accessory LHA from LGA and RHA from SMA) and IX (CHA from SMA) were uncommon variants with 3 cases (1.7%) for each type being recorded. Prevalence of these variants were 1%, 2% and 4.5% in study by Michel et al.; 2%, 2.6% and 1.3% in study by Keles, et al. and 2%, 1% and 4% in study by Duran et al, respectively.[15, 22, 25]

Apart from ten anatomical variations of celiac and hepatic artery as described by Michel our study showed 3.4% had different variant anatomy that is not included in Michel's classification, e.g. Common celiac and superior mesenteric trunk from aorta, common hepatic artery directly originating from aorta, replace RHA from superior pancreaticoduodenal artery and LHA from LGA. Similar unclassified variant anatomy is also reported in other studies with prevalence of 0.4 to 3.5%. A angiographic study done by Koops, et al. among 604 patients showed prevalence of unnamed anatomical variation in 1.8% population.[21] A study by Keles showed prevalence of such unclassified group of variants to be as high as 10%.[22]

Though multiple literature can be found regarding prevalence of anatomic variation in celiac axis and hepatic artery in various study population, only limited studies have been carried out about the gender specific prevalence of these variation. One such study by Farghadani, et al. based on MDCT of 607 kidney donor and traumatic patient showed prevalence of anatomic variation of celiac axis and hepatic arteries and gender based distribution of these variants. They found the normal anatomic configuration of celiac axis and hepatic artery in 63.3% male and 64.1% female and variant anatomy was almost equally present in male and female population. In our study the 69% male and 64% female had normal anatomy of celiac axis and hepatic artery.[9] In our study showed patient with Type IV (LHA from LGA and RHA from SMA) and type IX (CHA from SMA) variation were all male and type VI (accessory RHA from SMA) variation was seen in female. However due to smaller population and lack of other studies conclusion about such gender specific variation cannot be done. This study was done among the patients presenting to hospital with health problem and thus may not represent the finding in normal healthy population.

Conclusion

Celiac artery and hepatic artery show marked anatomical variations. Variant anatomy is present in up to quarter of the population with almost equal distribution in male and female population.

Conflict of Interest

None

Funding

None

Author Contribution

Concept, design, planning: DM, NTS, AK, SG; Literature review: DM, AK, SG; Data collection: DM, NTS, AK, SG; Data analysis: DM, NTS, AK, SG; Draft manuscript: AK, SG; Revision of draft: DM, NTS, AK, SG; Final manuscript: DM, NTS, AK, SG; Accountability of the work: DM, NTS, AK, SG.

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