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Original Article

Origin and Prevalence of the Retroportal Course of Hepatic Artery- A Retrospective Study

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ABSTRACT

Introduction: Anatomical variations of celiac and hepatic arteries are relatively common and impact operative time and technique. Intraoperative identification of the entire course of these vessels can be a challenge due to limited surgical field and increases the chance of iatrogenic injury.

Aim: To evaluate and describe the origin and prevalence of retroportal course of hepatic arteries seen in Computed Tomography (CT) angiography in a large series of patients.

Materials and Methods: The present retrospective study was conducted in the Department of Radiology, affiliated to a tertiary cancer centre in Southern India. CT angiogram done between January 2020 to June 2021 were included. Total of 326 abdominal CT angiograms were studied for celiac axis variations, variations in the origin and branching pattern of hepatic arteries, trajectory of the hepatic artery and its relation to portal vein. The branching pattern of celiac axis was analysed with adherence to the modified definition of Common Hepatic Artery (CHA) and it was classified as normal/variant/ambiguous. Based on the origin and branching pattern, hepatic arteries were divided into standard/replaced/accessory and classic/variant divisions, respectively. Variant divisions include trifurcation, duplicate or double hepatic artery and late origin of Gastro Duodenal Artery (GDA). Retroportal hepatic arteries under each variation was identified separately and their prevalence calculated. Confidence interval was calculated using simple proportion-frequency analysis open Epi version 3 software.

Results: The age of the patients varies from 3-83 years (mean age 53.7 years). A 207 (63.49%) cases were male and 119 (36.5%) cases were female. A 262 (80.37%) cases had a normal celiac axis anatomy. Eight specific types of celiac axis variations were observed in 48 (14.72%) cases. In the remaining 16 (4.91%) cases, the celiac axis anatomy was ambiguous. CHA originated from the celiac axis, Superior Mesentric Artery (SMA) and aorta in 294 (90.18%), 10 (3.07%) and 6 (1.84%) cases respectively. Out of the 52 replaced Right Hepatic Artery (rRHA), 48 (14.72%), 3 (0.92%) and 1 (0.30%) cases had Right Hepatic Artery (RHA) replaced to the SMA, aorta and GDA, respectively. Except for the one rRHA from GDA, all of them had a retroportal course. Classic branching pattern of hepatic artery was seen in 154 (47.24%). Trifurcation, early branching of RHA and early branching of LHA were found in 49 (15.03%), 4 (1.22%) and 8 (2.45%) respectively. 63 (70%) cases of variations in hepatic artery origin, 15 (16.67%) cases of variations in hepatic artery branching and 12 (13.33%) cases of variations in celiac axis contributed to a total of 90 cases with retroportal hepatic artery. Prevalence of retroportal hepatic artery in the present study is 27.61% (confidence interval 22.82-32.8) and the most common cause was aberrant RHA origin.

Conclusion: Knowledge about the origin and prevalence of retroportal course of hepatic artery will help the surgeon to approach it systematically. Preoperative knowledge of the variations in origin and branching patterns and its influence on the trajectory will help in a better intraoperative identification of these variant vessels.

Keywords: Celiac axis variations, Computed tomography angiography, Hepatic artery variations

INTRODUCTION

Anatomical variations of celiac and hepatic arteries are relatively common. These variations have substantial impact on operative time and technique in hepatobiliary surgeries and interventional radiological procedures. Preoperative knowledge of the origin and course of these vessels are essential to avoid intraoperative injury and to have a good postoperative outcome [1,2]. Intraoperative identification of these vessels can be a challenge in obese patients, inflammation surrounding the biliary stent in preoperatively stented patients, mass at the porta displacing the vessels and also in patients with previous history of supramesocolic surgery. According to a 2002 study, the accuracy, sensitivity and specificity of CT Angiogram (CTA) to know the branching pattern and course of the celiac artery branches and Superior Mesenteric Artery (SMA) were 97%, 94% and 100% [3]. Few other studies done earlier also showed similar results [4-6].

With the present technical advances in the CT machine, the sensitivity can reach upto 100%. CTA also has an advantage over the conventional angiogram in demonstrating the course of these vessels, essential information for the surgeon.

Existing knowledge is that a normal hepatic artery originating from the celiac axis takes a preportal course and a replaced Hepatic Artery (rHA) takes a retroportal course. However, there are few exceptions to this as there are numerous celiac axis variations. The trajectory of the replaced hepatic vessels can be understood based on the embryological perspective. The primitive arteries that provide blood to the foetal liver are the left hepatic branch, medial hepatic branch, and right hepatic branch. Embryonic right hepatic branch arises from the omphalomesenteric artery, and takes a retroportal course. Omphalomesenteric artery will later become the SMA. At a later time, the left and right embryonic arteries involute, with persistence of medial hepatic branch which develops into Proper Hepatic Artery (PHA) [7]. Persistence of these embryonic arteries gives rise to accessory or replaced hepatic arteries.

Though there are many literatures available on the incidence of celiaco mesenteric axis variations [8-12], there are only few articles on the trajectory of these variant hepatic arteries and its relation to the portal vein [13-17]. The hypothesis is that the abnormalities of origin, branching pattern of celiac and hepatic arteries will overlap with the trajectory of the hepatic artery and its relation to portal vein. The primary objective of the study was to analyse the prevalence of retroportal hepatic artery and futher study the influence of variations in origin and branching pattern, over the trajectory of the hepatic artery and its relation to the portal vein.

MATERIALS AND METHODS

The retrospective study was conducted in the Department of Radiology, affiliated to a tertiary cancer centre in Southern India. CT scans done between January 2020 and June 2021 were retrieved from Picture Archiving and Communication System (PACS) and searched for abdominal CTA. Institutional review board approval was obtained for this study. Data collection and analysis was done over a period of one month after obtaining IRB clearance.

Inclusion criteria: All abdominal CTA, done between January 2020 and June 2021 were included in the study.

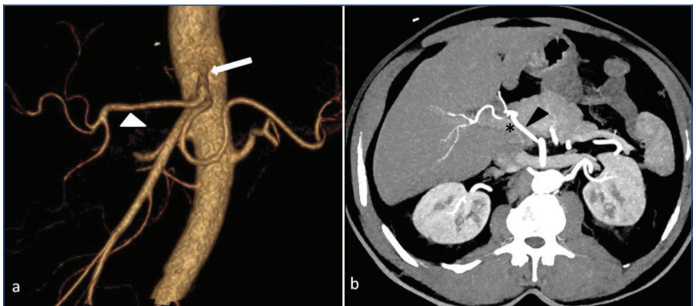
Exclusion criteria: Technically poor scans, large mass in the porta and patients with history of major supracolic compartment surgeries were excluded.

Study Procedure

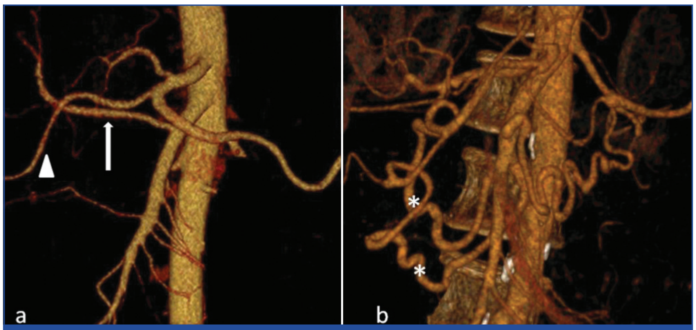
Total of 326 CTA were studied. As a routine practice, all the CTA for the hepatic vasculature were done by bolus tracking method with ROI kept in aorta [18]. The arterial phase was acquired after a delay of 9 seconds once the threshold in the aorta reached 100 HU. The raw imaging data of the arterial phase, the multiplanar and 3D reconstructed images were analysed for the celiac axis, SMA, Left Gastric Artery (LGA), Common Hepatic Artery (CHA) and splenic artery origins. Volume Rendered (VR) 3D images were used in evaluating the arteries with tortuous course and the sagittal Multiplanar Images (MPR) in easy identification of the LGA origin.

Key Definitions

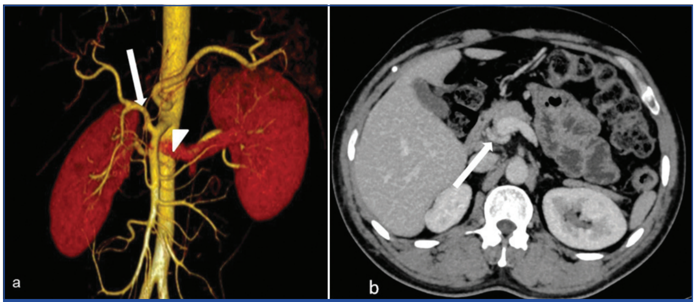
- Normal celiac axis [Table/Fig-1]: Common arterial trunk that branches off CHA, LGA, and splenic arteries (Sp A)
- Ambiguous celiac axis [Table/Fig-2] [8]: Congenital absence of CHA or persistent embryonic anastomotic channel connecting the celiac axis and SMA or CHA to the celiac axis and the SMA
- Hepatomesenteric Trunk (HMT)[Table/Fig-3]: CHA completely replaced to SMA
- Celiacomesenteric Trunk (CMT) [Table/Fig-4]: Celiac axis completely replaced to SMA
- CHA [8]: Arterial trunk giving rise to Gastroduodenal Artery (GDA) and Right Hepatic Artery (RHA) or Left Hepatic Artery (LHA), irrespective of the origin and anatomic course
- Standard hepatic artery: Arterial blood supply to the liver from celiac axis is only through CHA
- Replaced Hepatic Artery (rHA): Only hepatic arterial branch supplying to that portion of liver but with aberrant origin
- Accessory Hepatic Artery (aHA): Hepatic artery branch with aberrant origin, in addition to the hepatic artery with normal origin
- Classical division: CHA divides into GDA and PHA, and PHA further divides into RHA and LHA
- Trifurcation: No PHA. CHA trifurcates into GDA, RHA and LHA
- Late origin of GDA: No PHA. Early branching of RHA/LHA before GDA
- Double or duplicate hepatic artery [Table/Fig-5]: No CHA and PHA. RHA and LHA arises directly from the celiac axis or aorta and GDA originates from either of the hepatic arteries.



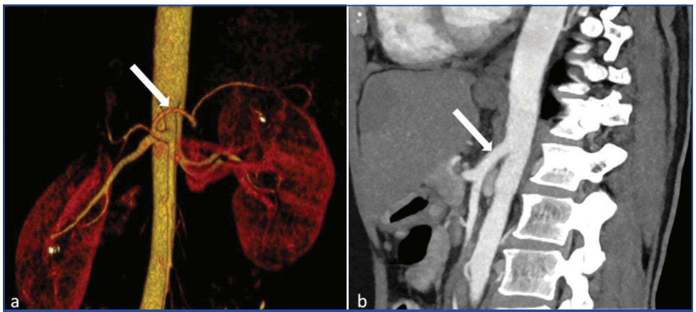
[Table/Fig-1]: Normal celiac axis and hepatic artery anatomy and its relation to portal vein (*). VR (a) and arterial phase CT scan; (b) image showing normal preportal course of common hepatic artery (arrow head) arising from the celiac axis (arrow).



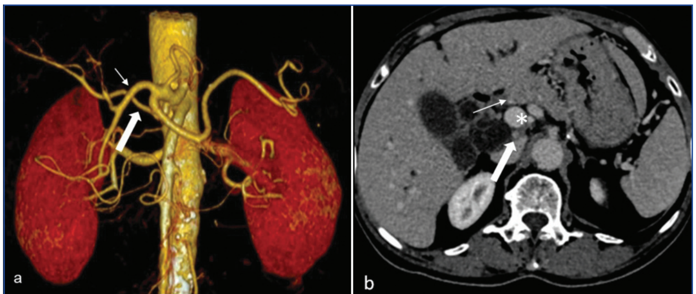
[Table/Fig-2]: Ambiguous celiac axis. VR images showing: (a) PHA (arrow) replaced to SMA and GDA (arrow head) separately originating from celiac axis; (b) absent celiac axis with reformation of its branches by pancreatoduodenal arcades (*).



[Table/Fig-3]: Hepatomesenteric trunk (HMT). VR (a) and axial CT; (b) images showing CHA (arrow) branching off from SMA (arrow head) and takes a retroportal course.



[Table/Fig-4]: Celiacomesenteric Trunk (CMT). VR (a) images and sagittal reformat; (b) showing a common origin (arrows) for celiac trunk and SMA.



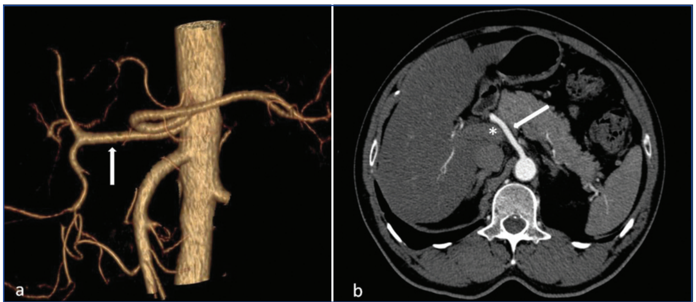
[Table/Fig-5]: Double hepatic artery. VR (a) and Venous phase CT; (b) image showing right and left hepatic arteries arising directly from the celiac trunk. LHA (thin arrows) is coursing anterior to portal vein (*) and RHA (Thick arrows).

Normal celiac trunk, also known as hepatosplenogastric trunk, refers to a common arterial trunk that branch off CHA, Left Gastric Artery (LGA) and Splenic arteries, while SMA originates separately from the aorta [Table/Fig-1]. The pattern of the aortic origin of these four major arteries were analysed with adherence to the modified definition of CHA proposed by Song SY et al., [8]. They further described the ambiguous celiac axis anatomy as: (i) absent CHA due to presence of persistent anastomotic channels; and (ii) absent CHA due to separate origins of the hepatic arteries and the GDA [Table/Fig-2]. Based on these definitions, celiac axis anatomy was classified as, variant or ambiguous [Table/Fig-6]. Relation of hepatic artery to portal vein was studied in each variant. Two types of persistent anastomotic channels are possible: (i) through a pancreaticoduodenal arcade [Table/Fig-2]; and (ii) through a vertical anastomosis like Arc of Buhler.

Types	Frequency n (%)	Relation of CHA to portal vein/SMV
Normal HSpLG+SMA trunk	**262 (80.37)**	
Variant	**48 (14.72)**	
HSp trunk+LG+SM	26 (7.97)	Preportal
HM trunk+GSp trunk	8 (2.45)	Retroportal
CM trunk	5 (1.53)	Preportal
HSpM trunk+LG	2 (0.61)	Retroportal
HM trunk+LG+Sp	1 (0.30)	Retroportal
CH+GSp trunk+SM	3 (0.92)	Preportal
HG trunk+SpM trunk	1 (0.30)	Retroportal
CH+LG+Sp+SM	3 (0.92)	Preportal
Ambiguous	**16 (4.91)**	

[Table/Fig-6]: Celiac axis origin and relation of CHA to portal vein.

After classifying celiac axis anatomy, CHA anatomy was analysed for its origin, trajectory, its relationship to portal vein/SMV and pancreas, and its branching patterns [Table/Fig-6]. Normal CHA arises from the celiac axis and courses along the upper border of the pancreatic head and anterior to the portal vein. Possible variant site of origin for CHA includes: (i) direct origin from aorta [Table/Fig-7]; (ii) origin from SMA [Table/Fig-3]; and (iii) LGA. Trajectory and portal vein relation of the CHA with variant origin was evaluated for the 5 possible anatomic courses [8]. They are supra/trans/infrapancreatic with relation to the pancreatic head, and pre/retroportal with relation to the portal vein/SMV.



[Table/Fig-7]: Absent celiac axis. VR (a) and arterial phase axial CT; (b) image showing LGA, CHA and splenic arteries arising directly from the aorta. CHA (arrow) takes a normal preportal course anterior to unopacified portal vein (*).

Based on the origin, hepatic arteries were divided into standard, replaced or accessory [Table/Fig-8]. Replaced and accessory hepatic arteries can take origin from: (i) SMA; (ii) aorta; (iii) LGA; or (iv) GDA.

Variant hepatic artery origin	Frequency n (%)	Trajectory and relation to portal vein
aRHA	**10 (3.07)**	
SMA	9 (2.76)	Retroportal
Aorta	0 (0.00)	-
GDA	1 (0.30)	Retroportal
rRHA	**52 (15.95)**	
SMA	48 (14.72)	Retroportal
Aorta	3 (0.92)	Retroportal
GDA	1 (0.30)	Preportal
aLHA	**15 (4.60)**	
LGA	15 (4.60)	Fissure for ligamentum venosum
Aorta	0 (0.00)	-
rLHA	**55 (16.87)**	
LGA	54 (16.56)	Fissure for ligamentum venosum
Aorta	1 (0.30)	Fissure for ligamentum venosum
rPHA	**2 (0.61)**	
SMA	2 (0.61)	Retroportal

[Table/Fig-8]: Variant hepatic artery origin, trajectory and portal vein relation.

The standard hepatic arteries were further subclassified based on their branching pattern to identify the influence of the branching pattern of CHA over the trajectory of the hepatic artery and its relation to the portal vein. Different branching patterns of standard hepatic artery includes classic, trifurcation, duplicate or double hepatic artery and late origin of GDA based on the presence or absence of CHA and PHA [Table/Fig-9] [13]. Late origin of GDA was further divided into early branching of RHA and early branching of LHA. The presence or absence of a middle hepatic artery was considered normal. In "late origin of the GDA", CHA is present, and RHA/LHA takes origin before GDA, and GDA may originate from either of the hepatic arteries. CHA in this variant is usually short and further divided based on the artery which originates first as: (i) early branching RHA; or (ii) early branching LHA. Whereas in the "double or duplicated hepatic artery", CHA is absent, the right and LHA branches take separate origin directly from the coeliac trunk and the GDA may originate from either of the hepatic arteries [Table/Fig-5]. Retroportal hepatic arteries under each variation were identified separately and their prevalence calculated [Table/Fig-10].

Types	Frequency n (%)	Retroportal hepatic artery
Classic division	154 (47.24)	1
Trifurcation	49 (15.03)	1
Late origin of GDA		
Early branching of RHA	4 (1.22)	3
Early branching of LHA	8 (2.45)	None
Double hepatic artery	9 (2.76)	9
Early branching of RHA and replaced LHA	1 (0.31)	1

[Table/Fig-9]: Variations in hepatic artery branching and portal vein relation.

Patterns	Frequency (n)	Percentage CI
Celiac artery variations with retroportal hepatic artery	12	3.68% 1.91-6.34
Variant HA origin with retroportal course	63	19.32% 15.18-24.04
Hepatic artery branching variations with retroportal course	15	4.6% 2.59-7.47

[Table/Fig-10]: Distribution of retroportal hepatic artery.

STATISTICAL ANALYSIS

Confidence interval calculated using simple proportion-frequency analysis open epi version 3 software [19].

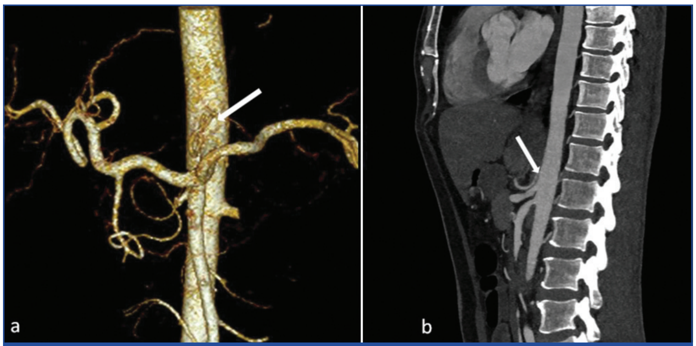
RESULTS

Origin and Branching Pattern of Celiac Axis [Table/Fig-6]

Fifteen types of celiac axis anatomy with an aortic origin of the major four arteries, including normal celiac axis, are theoretically possible [8]. Of the 15 celiac axis anatomy types, nine including normal celiac axis were identified in our study [Table/Fig-6].

Out of 326 abdominal CTA studied, 262 (80.37%) cases had a normal celiac axis anatomy. Eight specific types of celiac axis variations were observed in 48 (14.72%) cases. In the remaining 16 (4.91%) cases, the celiac axis anatomy was termed as ambiguous because the CHA was absent or persistent anastomotic channels were present. The most common celiac axis variation was a Hepatosplenic trunk (HSp trunk) with separately originating LGA and SMA, found in 26 (7.97%) cases [Table/Fig-11]. Incidence of less than 1% was found in 5 types of celiac axis variants. Sixteen cases had ambiguous celiac axis anatomy. The causes were absent celiac axis with persistent anastomotic channels, quadrification of celiac axis and hepatic arteries without a GDA component as found in one, one and fourteen cases respectively.

When the celiac axis was absent, as found in one case, its branches were filled retrogradely from SMA, through GDA by longitudinal and transverse pancreaticoduodenal arcades [Table/Fig-2]. In the



[Table/Fig-11]: LGA separately originating from aorta. VR (a) and sagittal reformat; (b) images showing LGA (arrrows) has a separate origin directly from aorta.

remaining 15 cases, CHA was absent. Absent CHA were due to quadrification of the celiac axis into RHA, GDA, LGA and Splenic arteries in one case and hepatic arteries without a GDA component in the remaining 14 cases. Among the 14 hepatic arteries without a GDA component, 12 (3.68%) had separate branching of the replaced right and left hepatic arteries from SMA and LGA, respectively while two cases (0.06%) had PHA totally replaced to SMA [Table/Fig-6].

To know the influence of variations in the celiac axis over the trajectory of CHA, the course of hepatic artery among the variant and ambiguous celiac axis were studied. Out of the 48 cases with variant celiac axis and 16 cases with ambiguous celiac axis, 12 cases were identified of retroportal hepatic arteries, primarily due to variations in celiac axis anatomy. Ten cases were due to CHA origin being replaced to the SMA, and two cases were due to branching variations in the celiac axis.

(i) **Replaced CHA origin with retroportal hepatic artery:** Replaced CHA (rCHA) origin can be from SMA or aorta. From SMA. rCHA was found to be the most common variant origin of CHA, found in 10 cases [Table/Fig-3]. In all these 10 cases, CHA had a retroportal course. Nine out of these 10 cases had suprapancreatic origin of CHA, running a short vertical course posteromedial to the superior mesenteric vein and main portal vein (retroportal). The remaining one case with infrapancreatic type origin had dual pathway with respect to the pancreas and SMV. The RHA arose as the first branch from the infrapancreatic HMT and had retro- SMV course, ascending posterior to the portal vein and supplying the right lobe of liver. Whereas the downstream hepatic artery took a lateral C-shaped loop in the pancreatoduodenal groove anterior to the pancreatic head, simulating the position of the GDA in the groove and ascended as LHA.

Six cases of CHA with a direct aortic origin were found, and all six of them had normal suprapancreatic preportal course, with its site of aortic origin close to the origin of the celiac axis equivalent.

(ii) **Branching variations of celiac axis with retroportal hepatic artery:** In two cases, hepatic arteries with celiac axis origin had retroportal course. In both these cases, the celiac axis had branching variations. One was a bifurcation of the celiac axis with Hepatogastric trunk (HG trunk) while splenic artery having a common origin with SMA forming Spleno Mesenteric trunk (SM trunk). The other was a quadrification of the celiac axis into RHA, GDA, LGA and Splenic arteries with retroportal RHA.

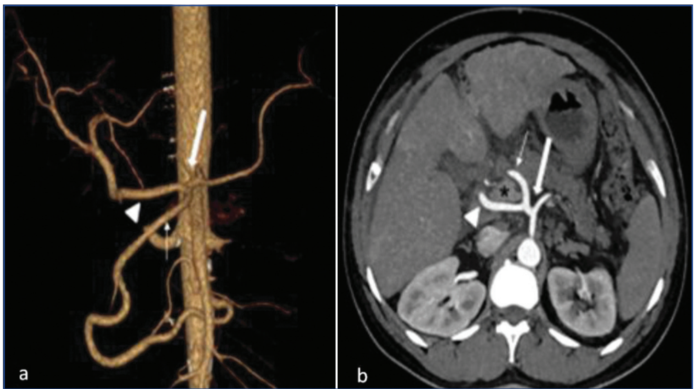
Thus celiac axis variations contributed to a total of 12 cases with retroportal hepatic artery. [Table/Fig-10].

Origin and branching pattern of hepatic artery [Table/Fig-8].

(i) **Variation origin of hepatic arteries and retroportal course-** To know the overlap between the hepatic artery origin and its trajectory, the origin of 324 hepatic arteries were identified and divided into: (i) standard hepatic artery origin from celiac axis; and (ii) replaced origin. The 2 cases excluded include absent celiac axis and quadrification of the celiac axis. Standard hepatic arterial anatomy was found in 224 cases (69.13%) and while the rest 100 (30.86%) cases had replaced origin of one or both hepatic arteries. Out of the 52 rRHA, 48 (14.72%), 3 (0.92%) and 1 (0.30%) cases had RHA replaced to the SMA, aorta and GDA, respectively. Except for the one rRHA from GDA, all of them had a retroportal course. Fifty five cases had rLHA and they did not affect the relation of hepatic artery with portal vein.

Accessory hepatic arteries (aRHA), if found, were evaluated separately for its origin, since they also contributed to the total number of retroportal hepatic arteries. 10 cases had aRHA originated from SMA and GDA, and all had a retroportal course [Table/Fig-8].

(ii) **Branching variations of hepatic artery and retroportal course:** Standard hepatic arterial anatomy was found in 224 cases (68.71%). Standard hepatic arteries were further divided into classic, trifurcation, duplicate or double hepatic artery and late origin of GDA. Classic branching pattern of hepatic artery was seen in 154 (47.24%) cases. Trifurcation, early branching of RHA and early branching of LHA were found in 49 (15.03%), 4 (1.22%) and 8 (2.45%), respectively. One case with a classic branching pattern had early branching GDA at a distance of 6.5 mm from the CHA origin and had a preportal course, while PHA had a retroportal course [Table/Fig-12]. Out of the 49 cases with trifurcation pattern, only one had retroportal hepatic artery. In 3 out of 4 cases with early branching of RHA before GDA, RHA had a retroportal course. When LHA branched off early before GDA, the downstream RHA had normal preportal course. In all nine cases of double hepatic artery variant from celiac axis, the GDA arose from LHA and had a preportal course, while RHA had a retroportal course. Apart from these patterns, 1 case had both variations in origin and branching while LHA origin was replaced RHA branched off early from CHA before portal vein crossing and had a retroportal course.



[Table/Fig-12]: Retroportal coursing PHA. VR (a) and Axial MIP (b) CT images showing short CHA (thick arrow) bifurcating into GDA (thin arrow), and PHA (arrow head) coursing behind the unopacified portal vein (*).

Distribution of the Retroportal Hepatic Artery

A total of 63 (70%) cases of variations in hepatic artery origin, 15 (16.67%) cases of variations in hepatic artery branching and 12 (13.33%) cases of variations in celiac axis contributed to a total of 90 cases with retroportal hepatic artery [Table/Fig-10]. Prevalence of retroportal hepatic artery in the present study is 27.61% (Confidence interval 22.82-32.8) and the most common cause was aberrant RHA origin.

DISCUSSION

Song SY et al., has published the largest series of celiac and hepatic artery variations using CT scan and digital subtraction angiography and classified the celiac artery origin into normal, variant and ambiguous anatomy [8]. In the present study findings in 326 cases were compared to prior work by Song SY et al., and Sureka B et al., who used the same classification strategy in 5002 and 600 cases respectively [8,12].

Normal, variant and ambiguous celiac axis anatomy was seen in 80.37%, 14.72% and 4.91% in the present study. The incidence of these three patterns was 89.1%, 9.64% and 1.26% in Song SY et al., 91%, 5.5% and 3.5% in Sureka B et al., study [8,12].

The HSp trunk with separate origin of LGA and SMA from aorta (7.97%) was the most common celiac axis variant in the present study [Table/Fig-6]. This was the most common variant in the previous two studies [8,12] also found in 4.42% and 2.83% cases, respectively. However, compared to the other two studies, our group exhibited a higher incidence of this pattern. The next common anatomic variation in present study was HMT and gastrosplenic trunk (2.45%) which was also found in Song Y et al., study (2.64%). Incidence of direct aortic origin of CHA, a rare variation, had an incidence of 1.84% in our study, whereas the other two studies had an incidence of 0.4% and 0.33%, respectively.

One case of congenitally absent celiac axis was found with reformation of its branches by retrograde filling through GDA from SMA by pancreaticoduodenal arcades [Table/Fig-2]. This rare anatomic variant has greater importance in surgical procedures like pancreatoduodenectomy that require GDA ligation. Tumour involvement of these communicating vessels makes the lesion unresectable or demands a major vascular reconstruction using grafts from aorta.

One case of rCHA from SMA had an infrapancreatic origin and its distal branches had dual relation with the SMV. While the RHA branches off first and maintains a posterior relation to superior mesenteric vein, the hepatic artery distal to it traversed through the anterior pancreaticoduodenal groove, where GDA is commonly found. A potential chance for mistaking the later branch for GDA and ligating it would result in compromised blood supply to the liver and biliary tract. Its origin from SMA near the neck of pancreas would also put them at risk of damage during neck transection or uncinate process dissection. An aberrant arterial course like this may demand a change in technique like infracolic SMA first approach during pancreatoduodenectomy, rather than a usual approach wherein SMA dissection is done as the latter part of the surgery [20].

All replaced and accessory right hepatic arteries originating from SMA and aorta had retroportal course. One replaced and one accessory RHA each, having origin from GDA had inconsistent relation to portal vein. While the former had a preportal course, the latter had a retroportal course. A rare variant of rRHA from SMA dividing into 2 branches and had dual relation to portal vein was found. This was not described before.

Variations in the branching pattern of hepatic artery include trifurcation, duplicate or double hepatic artery and late origin of GDA with an incidence of 15.03%, 2.76% and 3.68% respectively. Vandamme JP et al., reported their incidence to be 2%, 4% and 12%, respectively [17]. Late origin of GDA was further divided into early branching of RHA and early branching of LHA. Early branching LHA was more common than the early branching RHA in our study found in 2.45% and 1.22% of cases, respectively. They accounted for 10% and 2% of branching variants, respectively, in the Vandamme JP et al., study. One case with a classic branching pattern had a short CHA, with preportal course of GDA, while PHA had a retroportal course [Table/Fig-12]. This rare variation is not described by Vandamme JP et al [17]. We observed 75% of the cases with early branching RHA before GDA took a retroportal course, whereas 100% of the cases with early branching LHA had normal preportal course of both hepatic arteries.

Double hepatic artery was found in 9 (2.76%) cases. Though not mentioned in Michels classification, this variant was observed in many studies with an overall frequency ranging between 1 and 5% [9,14]. Importance of this variation includes the possibility of one hepatic branch being overlooked, when the catheter is advanced very far in selective angiographic study of the celiac trunk in various endovascular procedures of the liver. This variant is also helpful in living related liver transplants, where a long LHA pedicle allows retrieval of the left hemi liver without jeopardising the right hemi liver of the donor.

One case had variations in both branching and origin, where LHA origin is aberrant and RHA branched off early and had a retroportal course while GDA had a preportal course.

Aberrant RHA origin was found to be the single most common cause for retroportal coursing hepatic artery and contributed 70% of cases, while hepatic artery branching variations and celiac axis branching variations contributed 16.67% and 13.33% of cases, respectively.

Limitation(s)

The present study had some limitations, since it was based on only the analysis of CT images, description of fine arterial networks beyond the capability of CT examination could potentially be missed. However, in the current scenario, CT has largely replaced the conventional angiogram for diagnostic purposes, and presurgical planning in transplant and hepatobiliary surgery is entirely dependent only on CT. As a new nomenclature system for CHA was followed there was no comparison done between the present study and the other studies which used traditional classification.

CONCLUSION(S)

The CT angiography in preoperative evaluation of patients having liver transplant, hepatobiliary surgeries and interventional radiological procedures cannot be overlooked in today's scenario. Preoperative knowledge of the variations in origin and branching patterns and its influence on the trajectory will help in a better intraoperative identification of these variant vessels. To the best of the knowledge available, this is the first study of its sort to compare the overlap of the hepatic artery's retroportal path with the origin and branching variations of celiac and hepatic artery.

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