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Original Research Article

Normal and Variant Vascular Anatomy of Coeliac Artery and Portal Vein – Prevalence and Patterns in Indian Population

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Abstract

Background and Objectives: Upper abdominal vascular anatomy serves as a roadmap for interventional and surgical options for hepato-biliary, pancreatic pathology and liver transplant surgeries. The knowledge of variant vascular anatomy reduces the risk of inadvertent iatrogenic vascular injuries. This study aims to determine the prevalence and patterns of normal and variant anatomy of coeliac artery and portal vein among the Indian population.

Methodology: After obtaining clearance from institutional ethics committee, 200 patients who were referred for multiphase MDCT study of abdomen as a part of their managementwere enrolled. MDCT abdominal angiography was performed using Philips Brilliance 256 slice CT machine with intra-venous administration of non-ionic iodinated contrast havingIodine content of 300mg% at 1.5ml/Kg body weight using automated pressure injector at rate of 4.5ml/min. Arterial phase and portal venous phase images were obtained using thebolus tracking technique.

Conclusion: CT Angiography is an accurate modality for evaluation of vascular anatomy andits variants of upper abdomen.

Keywords: CT, MDCT, DSA, MRI.

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Introduction

With the tremendous increase in number of liver transplants and with the adventof newer interventional and surgical options for hepato-biliary and pancreatic pathology, it is imperative to know the vascular anatomy of coeliac artery and portal vein in a patient, we also need to be aware of the possible variations [1]. In this regard digital subtraction angiography (DSA) is considered gold standard in the evaluation of vascular structures, however its invasive nature limits its role [2]. Themultidetector computed tomography (MDCT) and magnetic resonance imaging (MRI) allows non-invasive evaluation of vascular anatomy for pre-surgical planning. CT Angiography because of its high speed, better spatial resolution and ability to depict associated extra-vascular structures is now the first step in evaluation of upper abdominal vascular anatomy [3] The vascular imaging information acts as a road map for surgical and interventional procedures. Variant hepatic artery and portal vein not only dictates the interventional or surgical technique but also predicts the risk of complications. This allows interventional radiologist and surgeon to choose the best therapeutic approach, to reduce complications, and to identify the anatomic variations requiring special attention during the procedure [4]. While a number of studies have been published in Western and South Asian literature, only limited data on anatomy and variations of both Coeliac artery & portal vein in a single study derived from Indian population is available presently.

Objectives

- To evaluate the vascular anatomy in early arterial and portal venous phase of upper abdomen using bolus tracking method on 256 slice MDCT.
- To determine the prevalence of normal and variations in the anatomy of
- Coeliac artery, Portal vein

Material and Method

The study was conducted at Banaras Hindu University Varanasi UP. All patients referred for abdominal MDCT triple phase study for valid clinical indications were included in the study.

Inclusion Criteria: All patients referred for MDCT multiphase abdominal angiography at Dept of Radio-Diagnosis of BHU during the study period of Two Years.

Exclusion Criteria: Patients with history of major upper abdominal resectional surgery.Patients with known abdominal arterial/venous occlusive disease. Patients with allergy/ contraindication to iodinated contrast.

Method of Collection of Data

MDCT abdominal angiography was performed using Philips Brilliance 256 sliceCT machine, by intravenous administration of non-ionic iodinated contrast medium having Iodine content of 300mg% using automated pressure injector and bolus tracking method for scan triggering. 1.5 ml/kg of iodinated contrast was administered at a flow rate of 4.5 ml/second. Imaging data was acquired 100-120 kV, 200-280 mA, Slice thickness of 2mm. Arterial phase images were obtained at 10-15 seconds and portal phase images at 40-45 seconds after descending aorta enhancement to 110HU, using the bolus tracking technique. Total cases of Two Hundred.

For Coeliac artery variation:

For Qualitative variable Sample size = $Z\alpha^2$ P(1-P) $_d2$

Zα = Standard normal variation at 95% is 1.96P = Prevalence

d = Absolute error

Eg: Variation in Coeliac artery = 57% With error of 5% sample size would be

Sample size with 5% error=$\frac{3.8416 \times 0.57 \times 0.43}{0.0025} = \frac{0.9416}{0.0025} =$ **377**

Sample size with 10% error= $\frac{3.8416 \times 0.57 \times 0.43}{0.01}$	=	$\frac{0.9416}{0.01}$	= **94**

For Portal vein variation
For Qualitative variable
Sample size = $Z\alpha^2$ P(1-P) $_d2$

Zα = Standard normal variation at 95% is 1.96P = Prevalence
d = Absolute error
Eg: Prevalence of portal vein variation = 18.5%
With error of 5% sample size would be

Sample size with 5% error=$\frac{3.8416 \times 0.185 \times 0.815}{0.0025} = \frac{0.5792}{0.0025} =$ **232**

Sample size with 10% error= $\frac{3.8416 \times 0.185 \times 0.815}{0.01} = \frac{0.579}{0.01} =$ **58**

Based on this sample size formula, 200 cases were selected for the study.

Results

The total number of patients studied were 200 in our series. The scans were obtained inarterial & portal venous phase using bolus tracking method. The raw images were processed in workstation for multiplanar reformation, 3D reconstruction, maximum intensity projection (MIP) & volume rendering. There were 58 females & 142 males inour study. The median age of the participants was 47.2 years, with age ranging from 10 years to 87 years.

The Coeliac artery and the hepatic artery variations were defined & analysed asper the criteria laid by Song et al and Michel respectively. Type I Coeliac artery wasseen in 172(86%) patients. Variations in coeliac was observed in 28 (14%)cases. Out of 14 possible Coeliac artery variations, 6 types of Coeliac artery variationswere seen in 22 (11%) patients. In the remaining 6 patients, the Coeliac artery anatomy was classified as ambiguous as per the definition provided by Song et al. The most common type of Coeliac artery variation was type II, i.e. LGAdirectly originating from aorta with hepato-splenic trunk & SMA, was seen in 8 (4%) of patients. Type III variation, i.e. Hepatomesentric trunk with gastrosplenic trunk wasseen in 5 (2.5%) cases. Coeliacomesentric trunk (Type IV) variation was seen in 3 (1.5%) of cases (Figure-21). Hepatosplenomesentric trunk (Type V) with separate origin of left gastric artery from aorta was seen in 2 (1%) of cases. Separate origin of common hepatic artery from aorta with gastrosplenic trunk (Type VII) was seen in 2 (1%) of cases. Hepatogastric trunk with splenomesentric trunk was seen in 2 (1%)of cases. Rest of the eight variations were not observed in our study. In our study 6 (3%) cases of ambiguous variations were observed. Double hepatic arteries were seen in 3 (1.5%) patients, in two cases there was absenceof CHA due to origin of gastroduodenal artery from coeliac trunk and in another case due to origin of gastroduodenal artery from splenic artery. In one caseof coeliac mesenteric trunk, there was early branching of

RHA from Coeliac artery partof coeliacomesentric trunk.

Portal vein formation, course & branching pattern as per Couinaud & Covey at al respectively was studied. Type I (Normal) portal vein formation was seen in 111 (55.5%) of patients. Type II was the most common variations in portal vein formation, seen in 64 (32%) patients Type III was seen in 25 (12.5%) of patients. No type IV variation in portal vein formation was seen. Normal intrahepatic PV branching patterns were identified in 145 (72.5%) of patients. PV variations and anomalies were identified in 55 (27.5%) patients The most common main PV variation was type 2 (trifurcation) whichwas observed in 24 (12%) patients. The second most common variation was type III, which was noted in 19 (9.5%) patients. Type IV variations were seen in 9 (4.5%) of patients. Type V was seen in 1 (0.5%) of patients. Two other variations were seen. Segment VIII branch arising from LPV was seen in 1 (0.5%) of patients. In one (0.5%) cases segmental variations of RPV was seen, in the form of separate origin of seg VI & seg VII from RPV

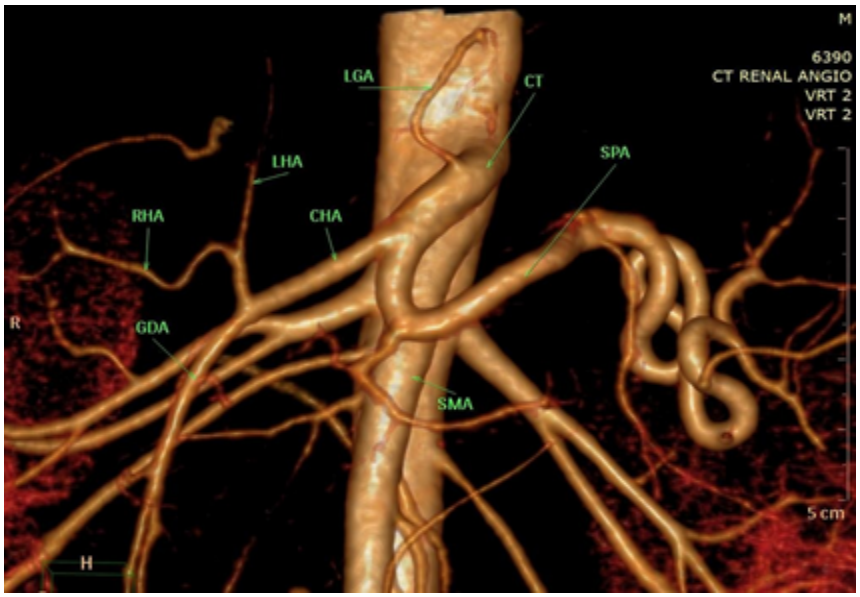

Figure 1: CT Angiogram, volume rendered image showing normal Coeliac Artery and hepatic artery branching with Early Branching of Left Gastric Artery.

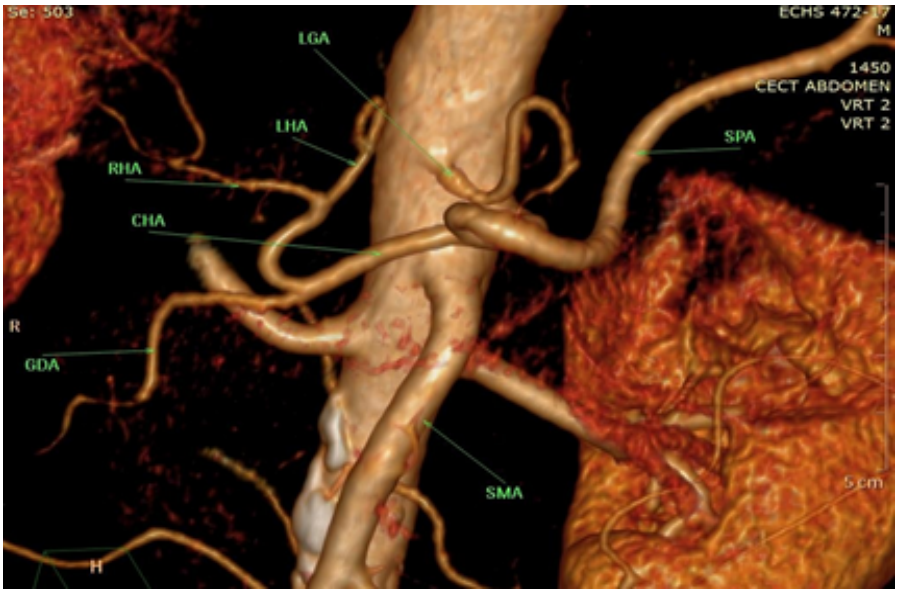

Figure 2: CT Angiogram, volume rendered image showing Hepatosplenic trunk withseparate origin of Left Gastric artery and Superior Mesenteric artery.

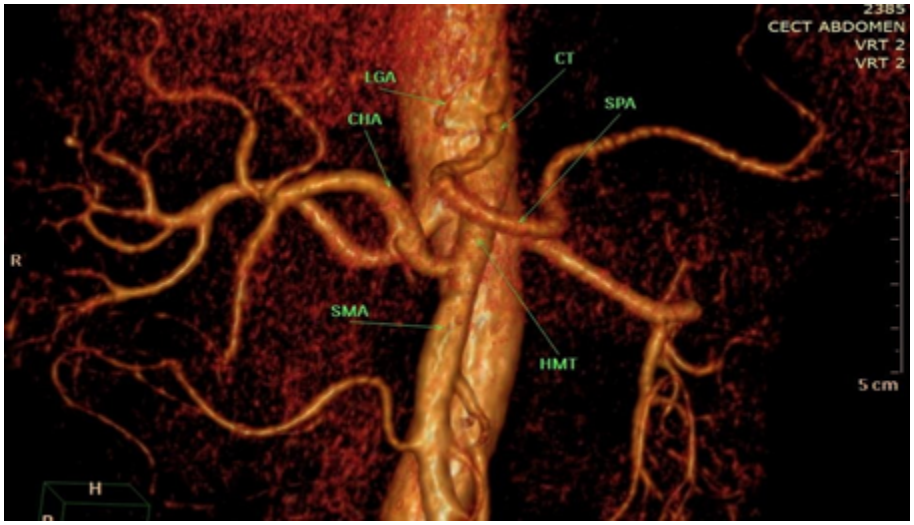

Figure 3: CT Angiogram, volume rendered image showing Hepatomesentric trunkwith Gastrosplenic trunk

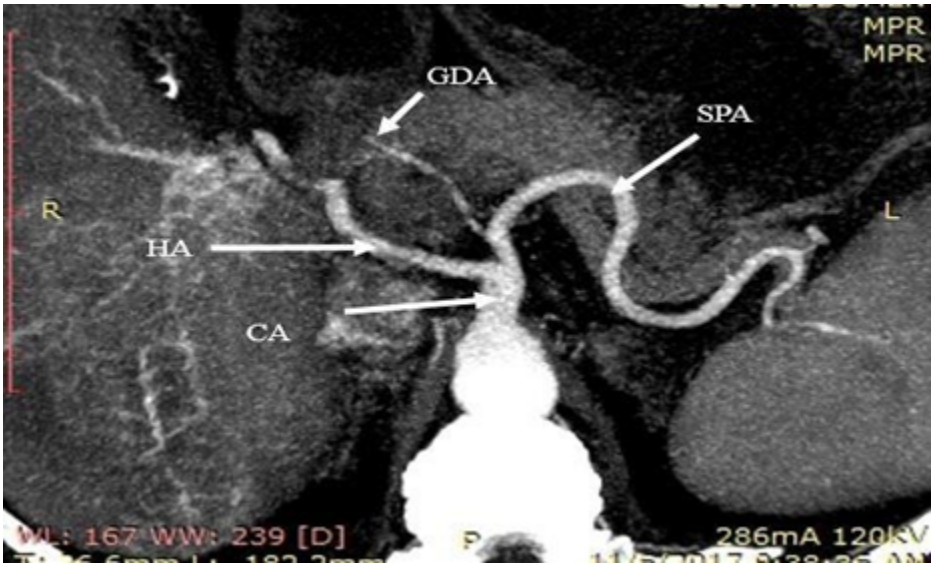

Figure 4: CT Angiogram, axial MIP image showing Gastroduodenal artery arisingfrom Splenic artery [Absent Common hepatic artery

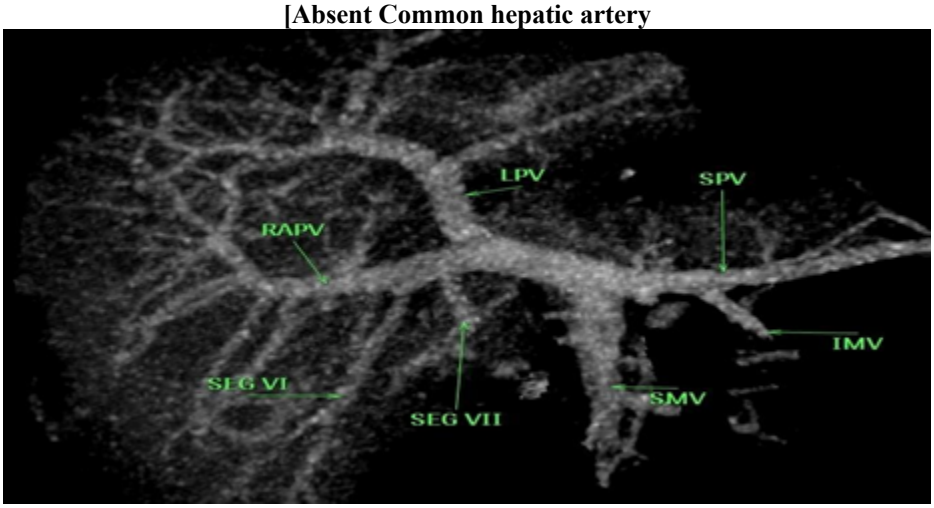

Figure 5: CT Portogram, MIP image showing Segment VI & Segment VII branchdirectly from Right Portal vein.

Discussion

Variations in Coeliac artery, hepatic artery & portal vein plays a critical role inevaluation before liver resection, liver transplant &interventional procedures like trans-hepatic portal vein embolization, trans-hepatic intraparenchymal portosystemic shuntsand intra-arterial chemo-embolization. There are various cadaveric & imaging-based studies been done to study the variations. only limited data derived from Indian population is available presently. Although 3D catheter angiography is gold standard in studying the vascular system, it is invasive & expensive. The various non-invasive imaging modalities available for evaluation of Coeliac artery & portal veins are Doppler ultrasonography,computed tomography & magnetic resonance. Ultrasound is user dependent & poor value in delineating subtle variations of Coeliac artery& portal veins. Magnetic resonance has the advantage of absence of ionizing radiation & improved tissue contrast, however due to its longer acquisition times, increased susceptibility & motion related artefacts, it is not the preferred no- invasive imaging modality for studying Coeliac artery& portal vein variations. MDCT is the preferred non-invasivemodality for imaging the Coeliac artery& portal vein variations due to its shorter acquisition time & 3D reconstruction capabilities. The disadvantages of MDCT include ionizing radiation, nephrotoxicity of iodinated contrast material & lack of qualitative flow information [5]. The Coeliac artery and the hepatic artery variations were defined & analysed asper the criteria laid by Song et al [6]. and Michel [7] respectively. The prevalence of normal coeliac artery in this study was 86%, this finding is comparable to the finding of Song et al type I coeliac, where they have reported a prevalence of 89.1%. Sureka et al had observed type I in 91% of cases, this result is par with this study [1]. The prevalence of type I coeliac artery branching was 89.5% in thestudy conducted by Arunthathy et al, which is corresponding to this findings8. Prakashet al found a prevalence of 86% of type I branching, this finding is equivalent to the prevalence in this study. The prevalence of type I was 90.5% in A.M Osman et al study which is comparable with this study. The prevalence of type I variation was 89% in study conducted by Ugurel et al, which is similar to our findings [2]. Lakshana etal found the prevalence of type I was 90.6%, findings parallel with this study. Out of 14 possible Coeliac artery variations, 6 types of Coeliac artery variations were seen in 22 patients. In the remaining 6 patients, the Coeliac artery anatomy was classified as ambiguous as per the definition.

The most common type of Coeliac artery variation was type II, i.e. LGA directly originating from aorta with hepato-splenic trunk & SMA, was seen in 8 (4%) of patients. This finding is in par with prevalence seen by Song et al, where they foundthe most common variation was type II with a prevalence of 4.42%. Even in study conducted by Sureka et al the most common variation was hepatosplenic trunk with a prevalence of 2.83%, which is comparable with our findings[1]. In study conducted by Prakash et al the most common variation was hepatosplenic trunk with a prevalence of4%, which is equivalent with our prevalence. In the study conducted by A.M Osmanet al the most common variation was gastrosplenic with a prevalence of 4.3% and theprevalence of hepatosplenic trunk was 2.8%, this finding doesn't correspond with our finding. Ugurel et al in their study found hepatosplenic trunk to be the most commonvariation, with a prevalence of 3%[2]. In the study conducted by Lakshana et al, the most common variation was hepatosplenic trunk with a prevalence of 8%, the prevalence ismuch higher than our finding. Type III variation, i.e. Hepatomesentric trunk with gastrosplenic trunk was seenin 2.5% of cases in our study. This observation is in agreement with the observation ofSong et al, were they had found a prevalence of 2.64%. The prevalence of type III was 0.66% in study conducted by Sureka et al, doesn't correlate with our findings[1]. Inthe study conducted by Arunthathy et al the prevalence of type III was found to be 1.5%, comparable with our findings[8]. In all the cases the portal vein had a retro-duodenal course, no variations in thecourse of the portal vein seen. Normal branching pattern of portal vein was seen in 145 (72.5%) patients. Thisis comparable with the findings of Sureka et al, they had reported a prevalence of 79.94%. Thomas et al & Zafer koc et al had reported a prevalence of 81.5% & 78.5% respectively, which is in par with our findings. Covey et al had reported 65%prevalence of type I, which is slightly lower than our finding [9].

The most common variant of portal vein branching in our study was type II, which was seen in 24 (12%) patients. This finding is equivalent to the finding of 12% prevalence observed by V Sharma et al [10]. Our finding is comparable with Thomas et al [11] and Zafer koc et al [12] finding, who had reported 11.5% and 11.1% prevalence respectively. Covey et al [9] and Sureka et al [13] had reported 9% and 6.83% prevalence, which is lower than our finding. Type III portal vein branching was seen in 9.5% of cases. This finding is comparable with Covey et al finding of 13% prevalence. Lower prevalence was reported by Sureka et al, Thomas et al and V Sharma et al [10], with a prevalence of 4.96%, 4.5% and 5% respectively. Type IV variation was seen in 4.5% of cases in our study. The lower prevalencehas been reported by Covey et al and Sureka et al, with a prevalence of 1% and 1.34% respectively. V Sharma et al had observed type IV variation in 7% of cases, which is higher prevalence rate than our study [10]. Type V variation was seen in 1(0.5%) of case in our study. This finding commensurate with the finding of Sureka et al, where they had reported a prevalence of 1.34%. Higher pre valence has been reported by V Sharma et al[10] and Covey et al [9],

with a prevalence of 5% and 6% respectively. Two other variations of portal vein branching were observed in our study. Onecase of segment VIII branch arising from LPV, with a prevalence of 0.5%. In the studyconducted by Zafer Koc et al the prevalence of this variation was 0.8%, which is in concurrence with our finding. This finding was not reported in the study by Sureka etal [13] & Thomas et al11. In another the segment VI and segment VII branches were separately arising from RPV, this variation had a prevalence of 0.5% in our study. Thisfinding is comparable with the findings of Sureka et al & Zafer koc et al [12], where theyhad reported a prevalence of 0.1%.

Conclusion

- CT Angiography is a valuable tool to study the vascular anatomy of upper abdomen.
- In this study the prevalence of normal coeliac artery anatomy is 86%, with hepatosplenic trunk as the most common variation with a prevalence of 4%.
- The prevalence of normal hepatic artery anatomy is 69.5%, with accessory left hepatic artery arising from left gastric artery as the most common variation, witha prevalence of 12%.
- Normal branching pattern of portal vein was seen in 72.5% of cases.
- Trifurcation of portal vein into left portal vein, right anterior portal vein and right posterior portal vein was the most common variation with a prevalence of12%.
- We have also reported a rare variant of coeliac artery branching, in which seven branches including an accessory splenic artery is originating from coeliac artery.

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