ORIGINAL RESEARCH PAPER
Volume-9 | Issue-4 | April-2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

MULTIDETECTOR COMPUTER TOMOGRAPHY STUDY OF VARIATIONS OF HEPATIC ARTERIES AND ITS MORPHOMETRY

Anatomy

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ABSTRACT
Accurate delineation of hepatic arterial anatomy and occurrence of anatomical variations is pivotal to successful performance of surgical and endovascular procedures on the liver. Our study aims to evaluate the prevalence of various hepatic arterial variants in patients with abdominal trauma. Variants of hepatic arterial anatomy and morphometric analysis was done on 80 patients, normal anatomy was observed in 93.75% on CECT and remaining 6.25% showed variations, replaced left hepatic artery from left gastric artery and accessory left hepatic artery from left gastric artery.. There was no gender difference in branching pattern and for variations of hepatic artery. Morphometric analysis of the hepatic arteries on CT showed significant variations in evaluation of length and diameter in different type of hepatic arteries. A thorough knowledge of such variations will help the interventional radiologist to reduce or avoid misinterpretations and guide the hepatobiliary surgeons for performing safe surgeries.

KEYWORDS
Hepatic Arterial Anatomy ; Computed Tomography; Carcinoma. Liver Transplantation

INTRODUCTION
The liver is a highly vascular organ which has dual blood supply, 25% to 30% supplied by the hepatic artery and 70 to 75% supplied by portal vein.[1]

Liver is drained by three major hepatic veins: right, middle and left hepatic veins which ultimately drains into suprahepatic part of inferior venacava.

Because of its complex vascular anatomy there is high incidence of vascular variants. In one third of individuals hepatic artery variants has been reported and in 10-15% of livers right branch of portal vein variation is common. The hepatic venous anatomy is important to transplant surgeons during right lobe living donation which has to be assessed preoperatively.[2]

The functional anatomy of the liver is composed of eight segments each supplied by a single portal pedicle composed of hepatic artery, portal vein and bile duct. The right liver is divided into anterior (segments 5 and 8) and posterior (segments 6&7). The left liver is split into anterior (segments 3 and 4) and posterior (segment 2). Segment 4 receives recurrent branches from left portal pedicle. The caudate lobe (segment 1) receives both from right and left portal pedicles.

These segments form the basis of liver resection as defined in the various hepatic surgeries like hepatectectomy, segmentectomy & liver transplantation.[3,4]

Hepatocellular carcinoma accounts for 85%–90% of all primary liver cancers and is a significant cause of morbidity and mortality worldwide.[5] The reported incidence rate of hepatocellular carcinoma in India for men ranges from 0.7 to 7.5 and for women 0.2 to 2.2 per 100,000 population per year.[6]

Portal hypertension is caused due to Budd Chiari syndrome, cirrhosis of liver, veno-occlusive disease, and congenital hepatic fibrosis. The life saving procedure to prevent esophageal variceal bleeding is trans jugular intraportosystemic shunt(TIPS). To decide the size of stent accurate dimensions of portal veins and hepatic veins is important for successful portocaval shunting procedure.[7]

Adequate knowledge of normal vascular anatomy and any variation in its branching pattern will help for correct interpretation of radiological reports and planning of liver surgeries. The present study aims to review the normal distribution, variation and morphometry of hepatic arteries of liver by contrast enhanced CT scan method.

MATERIAL AND METHOD
Type of study: Cross sectional study

Inclusion criteria: All the abdominal contrast enhanced CT scan images without liver lacerations were included for the study.

Exclusion criteria: Those patients with extrahepatic malignancy, cholangiocarcinoma or diffuse portal vein (PV) thrombosis were excluded from the study.

Contrast Enhanced CT was performed on Philips Ingenuity Core 128 (Philips Healthcare Co., Ltd, PMS, Cleveland Inc, US). 80ml of non-ionic iodinated contrast media was injected via through an 18 to 20-gauge antecubital intravenous cannula at a rate of 3.8ml/sec with dual head pressure injector (Ultravist 300, with 50 ml saline flush as per body weight). Scans were obtained in arterial and venous phase with the threshold set at 120HU. Examination parameters were 0.75s rotation time, pitch and speed of 1.014, 3mm section thickness, 1mm reconstruction interval, 120 kVp and 250mA. Additional images were reconstructed with 0.625mm reconstruction intervals for detailed interpretation. The raw imaging data obtained from MDCT were processed on a commercially available workstation for axial, coronal and axial oblique and multiplanar reformation (MPR), maximum intensity projection (MIP) and volume rendering (VR) images. Definitions of proper hepatic artery and its branches were observed by skilled Radiologists and variations of the same were documented. Axial source images remained the basis for observing vascular anatomy, however post processed 2D and 3D reformations contributed for accurate evaluation. The morphometric measurements of vessels (length, diameter) were analyzed in sagittal and coronal planes of multiplanar processed images(MPR).

RESULTS:
Extrahepatic branching pattern of hepatic artery
The extra-hepatic branching pattern of the hepatic artery was studied by CECT scan method in 80 subjects (47 Males and 33 Females). In the present study normal anatomy was observed in 75. 93.75% cases by CECT scan method (Figure 1), while the remaining 6.25% showed variations by CECT scan method. The variations noted in this were replaced left hepatic artery from left gastric artery Type II and accessory left hepatic artery from left gastric artery Type V. There was no gender difference in branching pattern and for variations of hepatic artery.

Table 1:Frequency of Hepatic artery variants by CECT scan method

	Types	No. of cases	Total in percentage %
CECT scan method	Type I	75	93.75
	Type II	4	5
	Type V	1	1.25

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

Intrahepatic branching pattern of hepatic artery by CECT scan method

In the current study 75 cases (93.75%) displayed normal anatomy by CECT scan method. The proper hepatic artery divided into right and left hepatic arteries. The right hepatic artery divided into right anterior and right posterior divisions supplying segments V, VIII and VI,VII respectively. The left hepatic artery supplied segments II, III and IV. In 8 cases (20%), the origin of middle hepatic artery varied; in 5 cases, it was given off from right hepatic artery, in another 3 cases from the bifurcation of right hepatic artery and left hepatic artery (Figure 2)

Morphometry of hepatic arteries

The length and diameters of PHA, RHA and LHA were measured in cms by CECT scan method. There was significant difference observed in both the parameters ($p < 0.05$) as shown in Table 2

Table 2: Showing Mean± SD for length and diameters of hepatic arteries by CECT scan method (n= 80)

Parameters	Methods	CECT Method			
		Min-Max	Mean ±SD	|Z|	p-Value
Length (in cms)	PHA	2.2-3.5	3.1±10.198	7.735	0.000**
	LHA	2.2-5.2	2.99±0.742	8.063	0.000**
	RHA	2.0-3.2	2.49±0.341	7.862	0.000**
Diameter (in cms)	PHA	0.2-0.58	0.37±0.096	7.738	0.000**
	LHA	0.16-0.3	0.25±0.049	7.878	0.000**
	RHA	0.2-0.6	0.37±0.094	7.867	0.000**

*- Indicates significant at P< 0.05 , **- Indicates significant at P<0.01

The length and diameters of hepatic arteries (PHA, LHA, RHA) were compared for Type I , Type II and Type V variants in two different methods.. There was significant difference observed in length of left hepatic artery in Type II variant compared to Type I in both cast and CECT scan methods as shown in Table 3

Table 3: Showing comparison of length and diameters of hepatic arteries Type I vs Type II by CECT scan method.

Parameters	Methods	Type I	Type II	|Z|	p-value
		Mean Rank	Mean Rank		
Length (in cms)	PHA	39.30	53.13	1.197	0.231
	LHA	38.07	76.25	3.264	0.001**
	RHA	40.48	31.00	0.809	0.418
Diameter (in cms)	PHA	39.86	42.63	0.235	0.814
	LHA	39.40	51.25	1.011	0.312
	RHA	39.73	45.13	0.462	0.644

*- Indicates significant at P< 0.05, **- Indicates significant at P<0.01

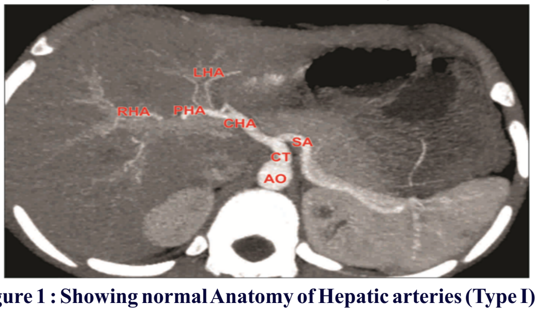

Figure 1 : Showing normal Anatomy of Hepatic arteries (Type I)

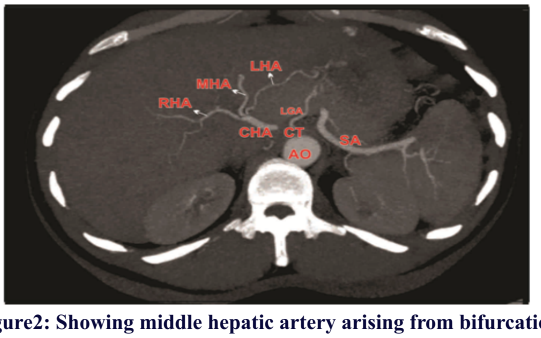

Figure2: Showing middle hepatic artery arising from bifurcation of right and left hepatic arteries

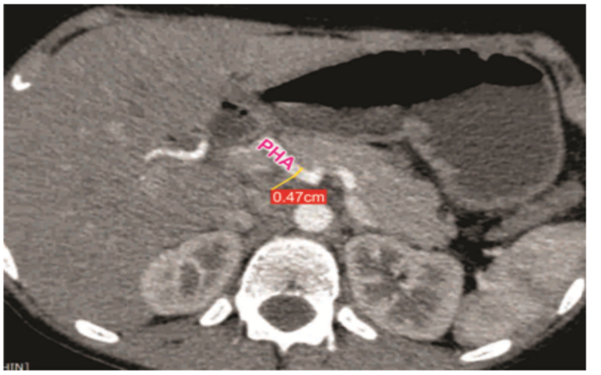

Figure 3: Showing measurement of proper hepatic arteries

DISCUSSION:

Usually the right and left hepatic arteries arise from the proper hepatic artery but it can also arise from either from common hepatic, superior mesenteric or left gastric arteries. The normal hepatic arterial anatomy occurs in approximately 50–80% of cases. The arterial pattern and its variations are of prime importance in planning and performance of surgical procedures like laparoscopic cholecystectomy, LDLT and interventional radiological procedures in the upper abdomen.

Replaced left hepatic artery usually arises from left gastric artery and has been classified as Type II as per Michel's and Hiatt's classification. In the present study replaced left hepatic artery was observed in 5% of the population. Type II variation has been reported by various authors like Lin and Chaikof in 25%, Chaib et al. in 3.3%, Sureka et al. in 10.8%, Yang et al. in 6.42%.[8, 9,10,11] Knowledge about the replaced left hepatic artery is vital, as there is an increased risk for inadvertent ligation of this artery during gastrectomy or hiatal hernia repair because of its proximity to the left gastric artery.[10] In the present study, accessory left hepatic artery arising from left gastric artery was encountered in 1.25%, which is in accordance to Lopez-Andujar et al. who reported in 3.8%.[12].

Artery to Segment IV

The middle hepatic artery or artery to segment IV may arise either from right hepatic artery or from left hepatic artery [13,14,] or directly from proper hepatic artery.[15]. In the present study in 8 cases (20%), the origin of middle hepatic artery varied; in 5 cases, it was given off from right hepatic artery in another 3 cases from the bifurcation of right hepatic artery and left hepatic artery. Ghosh reported that the middle hepatic artery arises more often from the right hepatic artery (52.8%) than from the left hepatic artery (47.2%). Wang et al. reported that the middle hepatic artery arising from the right hepatic artery in 58.3% and from the left hepatic artery in 36.9% which is similar to Ghosh .[16]. Kamel et al. reported that the artery supplying the segment IV arose from the right hepatic in 62.5% patients.[17] Jin et al. had reported that the artery to segment IV was arising from the right hepatic artery in 53.2% liver specimen, and from the left hepatic artery in 32.3% cases.

Sureka et al reported that the middle hepatic artery arising from right hepatic artery in 41.3% patients and from left hepatic artery in 27.83%.[8]

In contrary, Onishi et al. had reported that middle hepatic artery was arising predominantly from the left hepatic artery (61.5%) than from the right hepatic artery.[18] Similarly, Kishi et al. observed that middle hepatic artery was arising from the left hepatic artery in 62.5% cases and from the right hepatic artery in 37.5% of the cases. Yoshimura et al. also reported more number of middle hepatic artery arising from left hepatic artery.[19] Futara et al. noted that the middle hepatic artery was present in 47.3% of cases and was arising in equal proportion from the left hepatic artery (20%) and right hepatic artery (20%).[20.] Wang et al. observed that in livers that had a replaced left hepatic artery, the middle hepatic artery originated from the right hepatic artery and in livers that had a replaced right hepatic artery, it originated from the left hepatic artery.[16]

Knowledge regarding the arterial supply to the quadrate lobe or segment IV is very essential for minimising the postoperative complications. Saxena et al. reported that the quadrate lobe belongs functionally to the left lobe of the liver, hence during right lobe LDLT, preservation of the left hepatic artery and the middle hepatic artery is critical for adequate blood supply to the remaining left lobe in the donor.[21] In LDLT, injuries to the middle hepatic artery, which supplies the segment IV, may lead to a reduction in the functional volume of the left hepatic lobe and a decrease in the blood supply to bile ducts of this lobe. Complications of such arterial injuries, which may be severe, include insufficient hepatic volume, ischemic cholangiopathy, and hepatic artery thrombosis in the right lobe donor or the left lobe recipient.[22,23]

Guler et al. mentioned that in LDLT for the treatment of end-stage liver disease, right lobe is generally preferred as it provides a larger size liver graft. Though left lobe has been used for LDLT, it is not preferred because of 'small for size' syndrome and graft loss.[24] One of the most devastating complication in LDLT is the thrombosis of hepatic artery. Therefore knowledge about the variation in intrahepatic branching pattern is essential for the surgeons to avoid complication.

CONCLUSION

The present study highlights the intrahepatic branching pattern of the hepatic artery. Variations in the segmental supply was observed which has not been studied in detail previously in the Indian population. There was no gender difference in the branching pattern of both hepatic artery. A prior knowledge of such variations will help the interventional radiologist to reduce or avoid misinterpretations and subsequent misdiagnosis and help/guide the hepatobiliary surgeon in minimizing iatrogenic complications. It would also allow the surgeons to carry out a structured surgical procedure and bring about an improved and successful post-operative results.

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