Identification of Hepatic Arterial System Variations Using Multi-Detector Computed Tomographic Angiography

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Abstract- **Introduction:**Variation in hepatic arterial system (HAS) is common and has importance in preoperative planning to reduce the risk of accidental vascular injuries during surgical and radiological intervention of the liver. The aim of this study was to measure the prevalence of celiac trunk and describe different types of variations using Computed Tomographic angiography (CTA). **Materials and Method**: This is a retrospective cross sectional study. CTA images were retrieved from June till September 2017. Images were reconstructed in 3-dimensional volume reformatted (3D VR) format using workstation and reviewed for the variations of HAS. The results were calculated using IBM SPSS version 22. **Results:** A total of 117 patients were included in this study. Mean age was 58 (SD=14.4) years and male/female percentage was 66/34. Anatomical variation in the HAS was found in 35 (29.9%) cases. The most common variation found was (Michel's type V) in 9 (7.7%) cases followed by (Michel's type III) in 6 (5.1%) cases. Accurate knowledge and identification of anatomical variations in the HAS is crucial before undergoing any surgical or invasive imaging procedure. This can help surgeons and interventional radiologists to prevent accidental vascular injuries and perform a safe procedure..

Keywords- Anatomical variation, Common Hepatic Artery, Left Hepatic Artery, MDCTA, Right Hepatic Artery

I. INTRODUCTION

The accurate knowledge about HAS variation is extremely important in any surgical procedures of upper abdomen such as hepato-biliary, pancreatic surgery, as well as in interventional radiological procedures [1-3]. In particular, in the liver transplantation procedure, it is crucial to have accurate knowledge of the arterial anatomy of the liver to plan the best resection approach and to minimize the risk of accidental vascular injuries [4, 5]. Similarly, when treating isolated liver tumors or performing partial hepatectomy, an accurate depiction of hepatic arterial variants is helpful to make a safe surgical procedure [5, 6].

The liver has a variant blood supply. Saba et al has quoted Nelson et al report that in 25-75% of cases, the liver receives its arterial supply from branches of the celiac trunk (CT). In case of anatomical variation, the liver receives arterial supply via branches from superior mesenteric artery (SMA), left gastric artery (LGA) or directly from the abdominal aorta. These vessels may be totally replaced (representing the primary arterial blood supply to the liver) or accessory (occurring in addition to the normal arterial supply) [6].

During literature review many authors described several types of variations in order to introduce a single classification of the most common variations [7-9]. Michel described an internationally recognized classification in 1966. He carried out classic autopsy series of 200 cadaveric dissections, and defined the basic anatomical variations in HAS [9]. Recent advancement in imaging gives new clinical importance to the previous classical anatomic studies.

Multi-detector computed tomography angiography (CTA) is a non-invasive assessment of normal and variant hepatic arteries which provides high quality 3D reconstructed images [1, 6].

II. MATERIAL AND METHODES

A retrospective cross-sectional study was approved by the ethics committee. A total of 117 patients who underwent CTA (abdomen) for any reason including those who underwent computed tomography arterial phase performed for liver and renal protocol in HTAA, from June till September 2017 were included in the study.

The images were obtained using a 256-slice Siemens CT SOMATOM Definition Flash (Siemens, Erlangen Germany). Contrast used is non-ionic contrast, Iopamidol 300mgI/ml with total volume of 120ml. A dual head injector was used for the administration of contrast material, which allows the simultaneous injection of a compact iodine bolus followed by a normal saline bolus, both of them at the same injection rate of 4.5-5.0 ml/s.

The images were retrieved from Picture Archiving and Communication System (PACS), and transferred to Syngo via workstation for image reviewing. A multi-plane reconstruction (MPR) in the three spatial planes and three-dimensional reconstructions (3D) using maximum intensity projection (MIP) and volume rendering technique (VRT) was performed.

The origin of common hepatic artery (CHA), gastro-duodenal artery (GDA), right hepatic artery (RHA) and left hepatic artery (LHA) were identified and recorded for statistical analysis. Anatomical variations of the HAS were described according to Michal's classification as shown in Table 1 [9].

The prevalence of normal and variant anatomy of the HAS was measured by calculation of frequencies and percentages using Chi-square test in IBM SPSS statistics version 22. The level of significance lower than 5% (P<0.05) was considered statistically significant.

Ethical approvals for this study was obtained from International Islamic University of Malaysia (IIUM) Research Ethical Committee (IREC) and was registered National Medical Research Registration prior to conduct the study.

Table 1. Michel's classification of the HAS

Type = Michel's classification	**Description according to Michel's classification**
I.	Normal anatomy
II.	r-LHA from LGA
III.	r-RHA from SMA
IV.	r-LHA from LGA+ r-RHA from SMA
V.	a-LHA from LGA
VI.	a-RHA from SMA
VII.	a-LHA from LGA+ a-RHA from SMA
VIII.	a-LHA from LGA+ r-RHA from SMA
IX.	CHA from SMA
X.	CHA from LGA
Un classified	CHA from aorta

(r-LHA = replaced left hepatic artery, LGA = left gastric artery, r-RHA = replaced right hepatic artery, SMA = superior mesenteric artery, a-LHA = accessory left hepatic artery, a-RHA = accessory right hepatic artery, CHA = common hepatic artery)

III. RESULTS AND FINDINGS

There were 117 patients included in this study, where 77 (65.8%) were males and 40 (34.2%) were females. The mean (SD) age was 58 (14.4) years, the minimum age was 24 years and the maximum age was 82 years.

The prevalence of normal HAS variation (Michel's type *I*), where the CHA originated from the CT which then divided into GDA and proper hepatic artery (PHA), the latter then subdividing into RHA and LHA, was the most common variation in our study. It was found in 82 (70.1%) cases. On the other hands, the variations in HAS was found in 35 (29.9%) cases as shown in Table 2. The most common variation in our study was accessory LHA (Michel's type *V*) in 9 (7.7%) cases followed by replaced RHA (Michel's type *III*) in 6 (5.1%) cases as shown in Table 2 and Figure 1.

Table 2 CHA Variation According Michal Classification

Type of variations	Number of cases	Percentage	Cumulative Percentage
Normal pattern	82	70.1	70.1
r-LHA	5	4.3	74.4
r-RHA	6	5.1	79.5
r-LHA + r-RHA	5	4.3	83.8
a-LHA	9	7.7	91.5
a-RHA	4	3.4	94.9
a-LHA + a-RHA	2	1.7	96.6
CHA originates from SMA	4	3.4	100.0
Total	117	100.0	

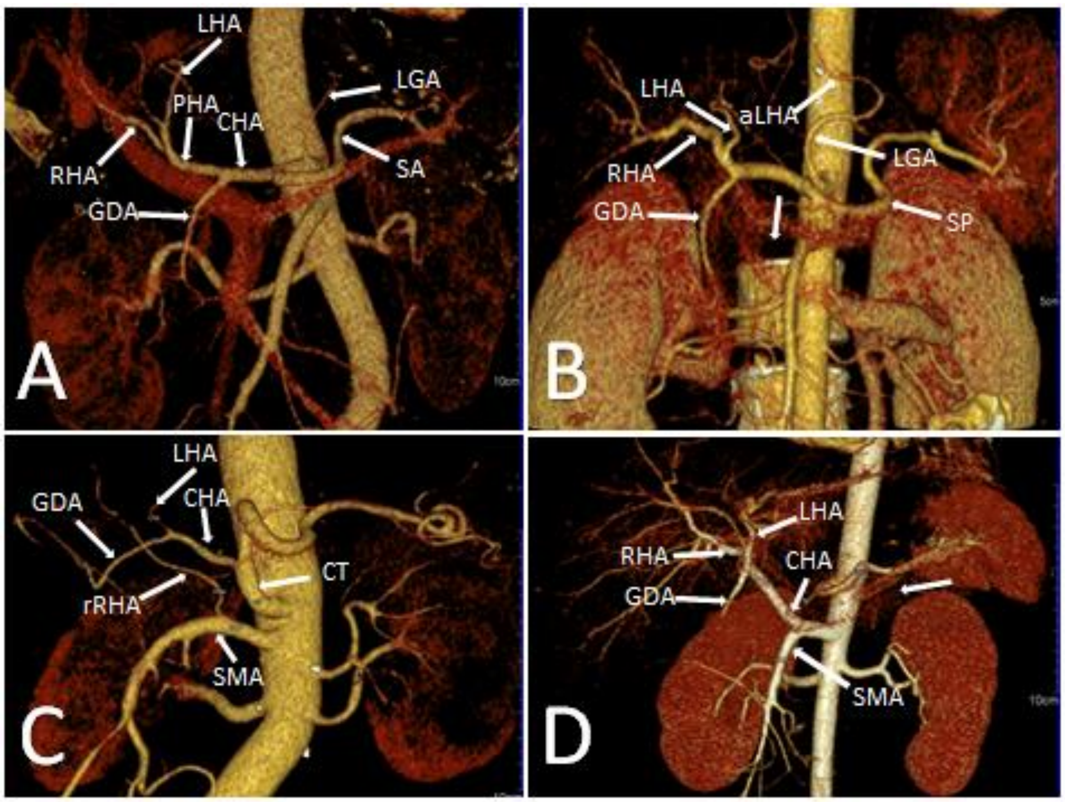

Figure1: A 3D- reformatted images. (A) Normal pattern of HAS (Michel's type *I*), CHA arises from the CT and giving off the GDA and then divides into RHA and LHA, with variant CT as celiac-colic trunk. (B) Variant HAS (Michel's type *V*), accessory LHA originates from LG. (C) Variant HAS (Michel's type *III*), replaced RHA originates from SMA. Note left side double renal arteries. (D) Variant HAS as hepato-mesenteric trunk (Michel's type *IX*) with variant CT as gastro-splenic trunk

A significant difference was observed in the point of origin of CHA as well as RHA and LHA. It was found that CHA was originated in 113 (96.6%) cases from the CT and in the remaining 4 (3.4%) from the SMA. In addition, in the majority of cases, the RHA originated from proper hepatic artery in 94 (80.3%) of cases, while from the CHA was observed in 10 (8.5%), and its origin from the SMA was present in 11 (9.4%) cases and only in two cases (1.7%) it was originating from the CT.
Moreover, LHA was originated from the PHA in 92 (78.6%) cases, while its origin from the CHA was observed in 15 (12.8%) and the remaining 10 (8.5%) cases depicted its origin from the LGA.

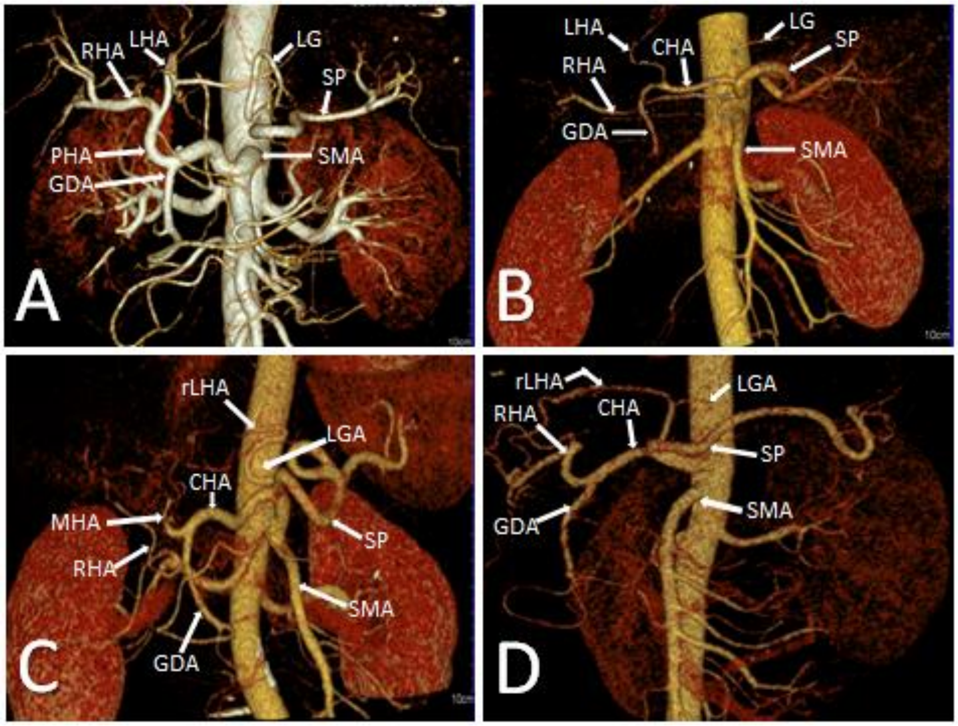

Figure 2: A 3D- reformatted images. (A) Variant HAS (Michel's type *IX*); CHA originates from SMA as hepato-mesenteric trunk with coexistence of gastro-splenic trunk and celiac-colic trunk. (B) RHA has replaced origin directly from the CT along with other three branches: CHA, LGA, SP. (C) Variant HAS (Michel's type *II*); the replaced LHA originates form LGA, where right and middle hepatic arteries arising from CHA. CT and SMA have a common point of origin from aorta as Celiac-mesenteric trunk. (D) Variant HAS (Michel's type *II*); the replaced LHA originates form LGA.

IV. Discussion

The mean age in our study was 58 years which shows similar results in other studies. It is because most people suffer from hypertension, aortic aneurysms, chronic liver diseases, renal problems in this age and refer to health centres and seek treatment [6].

Michel described anatomical variation of HAS in ten different types [9]. In this article we described our finding based on Michel's classification. Michel's type *I* was the most common type of HAS with 82 (70.1%) cases.

The prevalence of classical description where the liver takes its entire blood supply from right and left branches from the celiac hepatic artery reported by other authors ranging 25-75% [3, 6], The prevalence of anatomical variations in the HAS found in this study was found in 35 (29.9%) cases which is consistent with the results reported in other studies ranging 16-48%. Arifuzzaman et al reported 30.9% variations in HAS where the replaced RHA and LHA (Michel's type *IV*) was the most common variation [4]. Moreover, other studies done by Osman et al, Saba et al and Ugurel et al show almost the same results with 26.7%, 38.73% and 48% variations respectively [2, 6, 10].

The most common variation in our study was accessory LHA arising from LGA (Michel's type *V*) which was counted for 9 (7.7%) cases followed by the replaced RHA from SMA (Michel's type *III*) counted 6 (5.1%) of case and the least common variation was accessory RHA and LHA (Michel's type *VII*) in 2 (1.7%) cases. Prabhasavat et al reported 16% of all variations and Michel's type *III* was observed in 6% as the most common variation [11].

In our study we found that CHA originate from coeliac trunk in 113 (96.6%) cases. Song et al and Chen et al reported almost the exact percentage in their study of 5002 and 974 cases respectively. They found that CHA ~~was~~ originated from the SMA in 3.4% and 1.5% of cases respectively [5, 12]. However, the prevalence of this variation is rare and reported ranging 0.5% - 4.5% in other studies [3], Zagyapan et al reported 6.6% of this variation [13].

In addition, it was found that RHA originat directly from the CT apart from the three main branches in two (1.7%) cases. In 11 (9.4%) cases it was arising from the SMA. A similar result was reported by Olewnik et al and Kamath et al. They reported the origin of RHA form CT in three (7.5%) cases and four (10%) cases [3, 14]. Zagyapan et al reported the origin of RHA from SMA 17.8% [13]. Moreover, in our study it was found that LHA arise from LGA in 10 (8.5%) cases. Zagyapan et al reported this variation in 13.1% of cases [13].

One possible reason of this higher prevalence of the variation seen could be due to a relatively small number of studied populations compared to other studies. In addition, the sensitivity of the MDCTA is higher than cadaveric dissection, where small branches such as inferior phrenic arteries (IPAs) are difficult to preserve during dissection. this is the first reported study in a single institution at Kuantan population and previous reports of different prevalence had been documented among different countries [15].

V. CONCLUSION

Anatomical variations in hepatic arterial system can be found in three out of 10 patients based on this study from a single institution in Kuantan. Accurate knowledge about these variations is important and can help surgeons and interventional radiologists to prevent iatrogenic vascular injuries and perform safe procedure.

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