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Prevalence and Anatomical Variations of Middle Hepatic Artery: A Cadaveric and Radiological Study

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ABSTRACT

Background

Middle Hepatic Artery is a hilar artery that supplies segment IV of the left hemi-liver. Anatomical Variations of this hilar artery has led to its classification into various sub-types based on its origin. Many studies have elucidated the surgical importance of MHA and in-depth knowledge of its variations is essential to minimize the morbidity during liver surgeries. In LDLT and during hepatic resections any injury to MHA and vascular compromise to Segment IV can bring in catastrophic consequences such as reduction in functional volume of left lobe in right allograft, possible graft loss in left allograft and ischemic cholangiopathy at all cases.

Methods

This is a cross-sectional study on 25 cadaveric Livers and 25 CECT- Abdomen arterial phase, a total of 50 Liver specimens at our center. The origin and course of MHA was accessed and characterized after meticulous dissection of cadavers and 3D reconstruction of CECT-Abdomen arterial phase. Collected data was entered and analyzed by using SPSS 16.

Results

Middle Hepatic Artery was present in 76% (With 95% confidence interval as 61.83% to 86.94%) of cases. MHA originated from RHA in 34% of cases; from LHA in 24% of cases; from RHA in presence of replaced LHA in 6%; from LHA in presence of replaced RHA in 8% and from non-left non-right hepatic artery along the axis of CHA in 4% of cases.

Conclusions

MHA is a hilar artery that predominately originates from RHA. It is very important for a surgeon to meticulously study the course of MHA in patients prior to liver surgeries using 3D-reconstruction of radiological images to minimize morbidities.

Keywords: anatomical variation; hepatectomy; living donor liver transplant; middle hepatic artery.

INTRODUCTION

Couinaud classification suggests segment IV as a part of left liver lobe.[1] According to Michels, Segment IV of the left hemi-liver is supplied by the Middle Hepatic Artery (MHA), a Hilar Artery.[2] There are many variations in origins of MHA which are classified differently by different authors. Wang et al. classified MHA into 5 sub-type which shows 43.7% MHA gets originated from RHA.[3] In cases of MHA originating from RHA, during hepatectomy right lobe resection can lead to regenerative problems and reduction in functional volume of remnant liver.[4, 5] Similarly, left lobe donations in LDLT can lead to possible graft loss.[6, 7, 8] Both because of vascular disconnection to the segment IV.[9, 10] Ischemic cholangiopathy and biliary leakage are dreaded complications at any instance since, bile ducts of segment IV is invariably supplied by MHA.[11, 12] No prior studies in Nepalese

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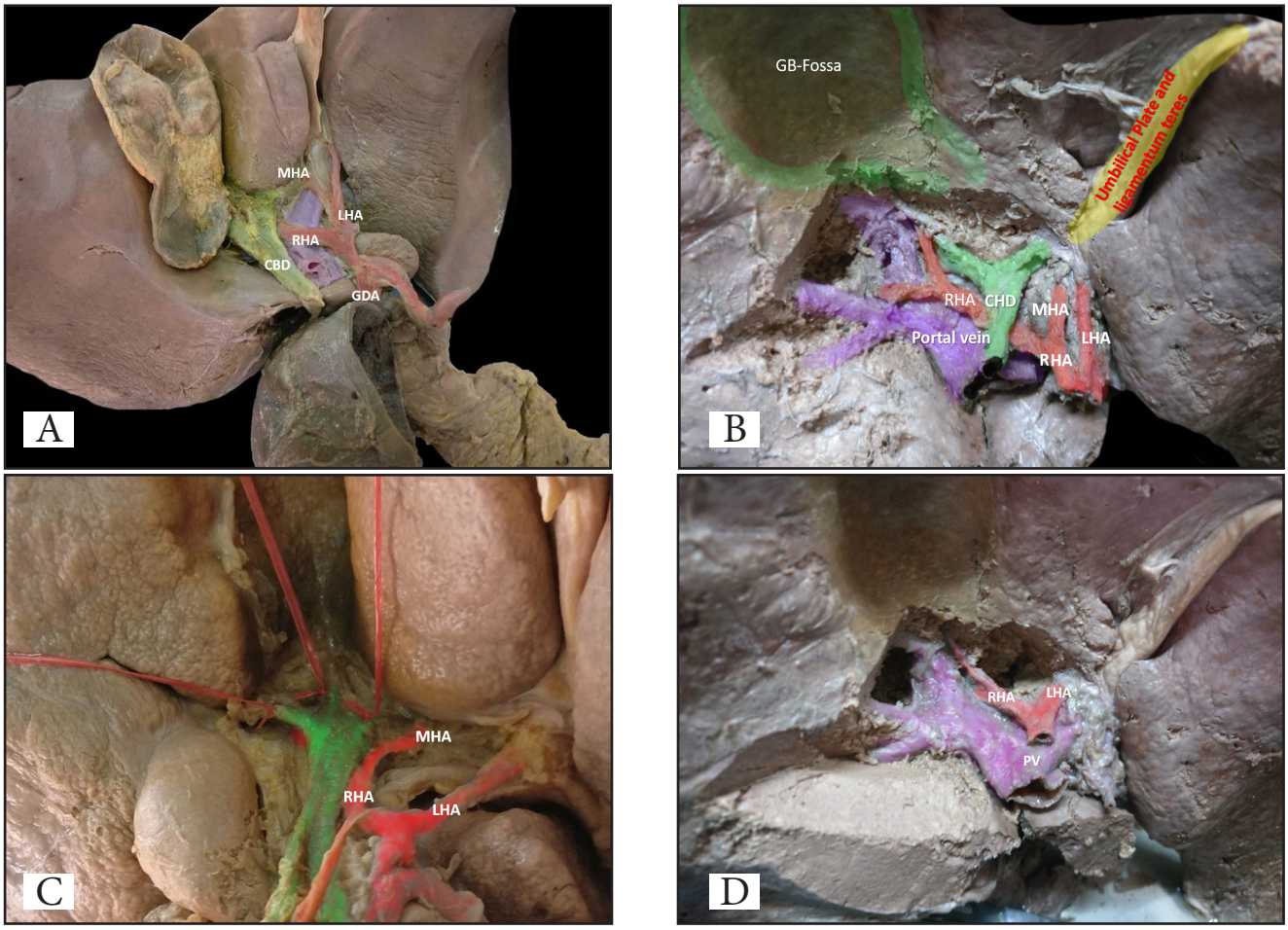

Figure 1. Cadaveric images of liver. 1A shows MHA originating from LHA, 1B shows MHA originating from RHA, 1C shows MHA originating from RHA and 1D shows absent MHA. (CBD-Common Bile Duct, CHD- Common Hepatic Duct, GDA- Gastro Duodenal Artery, LHA-Left Hepatic Artery, MHA-Middle Hepatic Artery, PV-Portal Vein, RHA- Right Hepatic Artery).

population describes the variations of MHA so this study aims to identify and classify the anatomical variations of MHA which could be useful in LDLT and hepatic resections.

METHODS

A crosssectional study was conducted in the department of GI and General Surgery, College of Medical Sciences Teaching Hospital, Bharatpur, Nepal. Ethical Approval from the Institutional Review Committee of the College of Medical Sciences Teaching Hospital (COMS-TH IRC) (Ref No.COMSTH-IRC/2023-59) data collection permisson was taken from concern authority of Hospital and Anatomy department of College of Medical Sciences. The study included 25 cadaveric livers from the Department of Anatomy of College of Medical Sciences Teaching Hospital and 25 patients who underwent a standard tri-phasic scan of Liver at the Department of Radiology of College of Medical Sciences Teaching Hospital. The Study was conducted in the Cadaveric lab of the Department of Anatomy at College of Medical Sciences Teaching Hospital, Bharatpur, Nepal. A total of 25 cadavers preserved in Formalin which were previously utilized for gross anatomical teaching to medical students were reutilized for this study. Only those cadavers with no history of liver abnormalities or prior liver surgeries with intact hilum were selected for the study. The porta hepatis and the portal triad were dissected to reveal the anatomical variations of hepatic arteries, their branches, the origin of MHA and its insertion into the liver parenchyma. The dissection was meticulously performed and the arterial branches supplying the segment IV were exposed by carefully removing the

liver tissues. The branch of the hepatic arterial system which dominantly supplied the segment IV of the left hemi-liver was defined as MHA in our study. All relevant information were filled into the case proforma following dissection. In this study, 25 patients who underwent a standard tri-phasic CECT abdomen from 21st August to 20th November, were accessed in the Department of Radiology at the College of Medical Sciences Teaching Hospital, Nepal. Patients in whom medical indication of CECT-Abdomen, early arterial phase were randomly selected. Poor quality images and images with artefacts were excluded for the selection of samples. CT Protocol and Processing of Image: Images were generated from 128-slice spiral CT-Scan. Standard CECT abdomen protocol was implemented. Post scan processing of images were undertaken in a commercially available workstation at College of Medical Sciences Teaching Hospital, Bharatpur. Image interpretation: Interpretation of each image was done in presence of an attending radiologist. Reconstructed images were reviewed to characterize the origin and course of the MHA. Relevant information was filled in the case proforma. Collected data were entered into the IBM SPSS STATISTICS 16 and electronically analyzed. Frequency and percentage of occurrence were analyzed and cross tabs for the entered data was produced using SPSS.

RESULTS

The prevalence of Middle Hepatic Artery (MHA) was found to be 38 (76%) (With 95% confidence interval as 61.83% to 86.94%) of specimens and was absent in 12 (24%) of specimen. MHA supplied the segment IV of liver in 100% of cases, i.e., in all 38 specimens with MHA. There were no instances of MHA originating from replaced or accessory hepatic arteries. The obtained results after analysis were classified as given by Wang et al.[3] Type I MHA, accounted for 34% (n=17) of specimen i.e. MHA originated from RHA in patients with normal hepatic arterial configuration. Type II MHA, accounted for 24% (n=12) of specimen i.e. MHA originated from LHA in patients with normal hepatic arterial configuration. Type III MHA, accounted for 6% (n=3) of specimen i.e. MHA originated from RHA in the presence of a replaced left hepatic artery.Type IV MHA, accounted for 8% (n=4) of specimen i.e. MHA originated from LHA in the presence of a right hepatic artery. Type V MHA, accounted for 4% (n=2) of specimen i.e. MHA originated from a non-left and non-right hepatic artery along the axis of the CHA, which included the CHA, the proper hepatic artery (PHA), and the right anterior hepatic artery (RAHA). In our study, In one specimen, the MHA originated from the hepatic artery proper, while in another specimen, it originated from the right anterior sectorial artery.

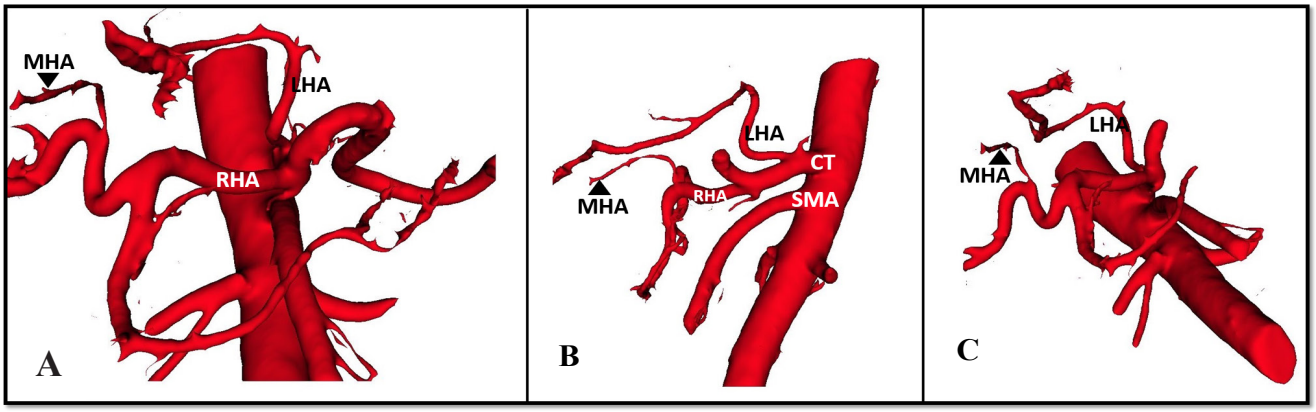

Figure 2. 3D reconstruction of the arterial system of liver showing MHA originating from RHA. In such situation taking right lobe as a graft, will disconnect arterial supply to segment IV. Hence reconstructing of the MHA is wise to prevent vascular complications. (CT-Celiac Trunk, LHA- Left Hepatic Artery, MHA-Middle Hepatic Artery, RHA- Right Hepatic Artery, SMA- Superior Mesenteric Artery).

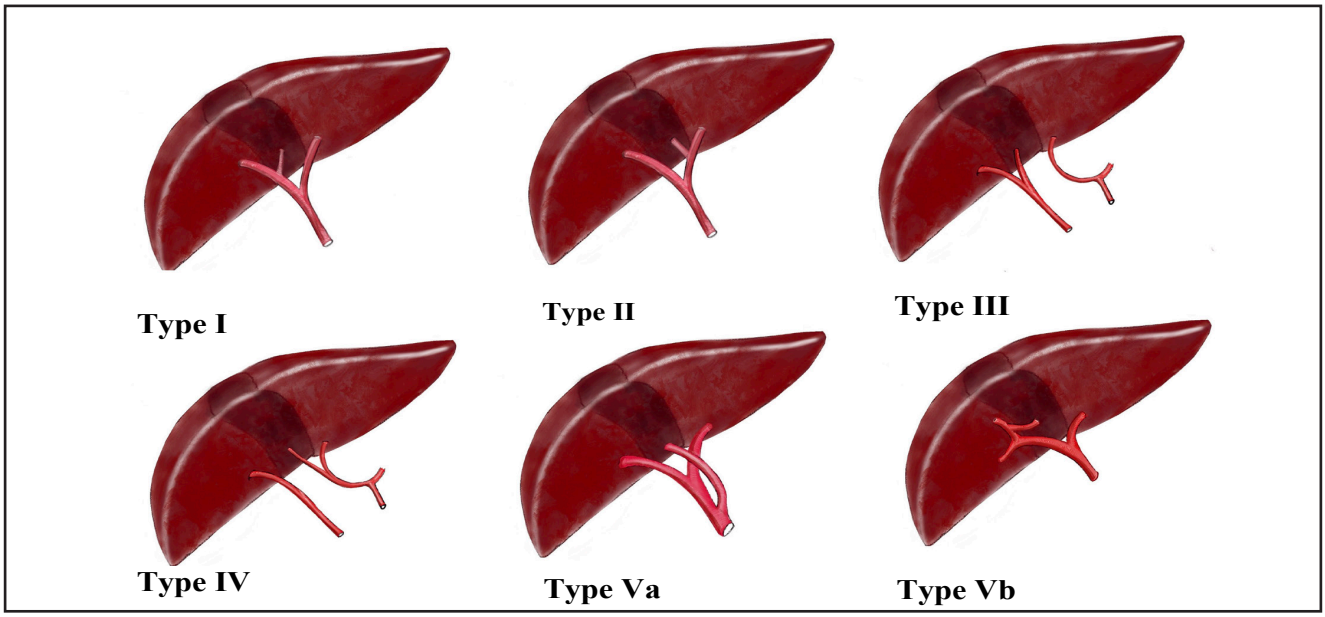

Figure 3. Variations in origin of MHA.

Table 1. Frequency of anatomical variation of MHA as observed in this study.

Type	MHA not accessible	MHA Type I	MHA Type II	MHA Type III	MHA Type IV	MHA Type V	Total
Cadaveric	5 (10%)	8 (16%)	6 (12%)	3 (6%)	1 (2%)	2 (4%)	25 (50%)
Radiological	7 (14%)	9 (18%)	6 (12%)	0	3 (6%)	0	25 (50%)
Total	12 (24%)	17 (34%)	12 (24%)	3 (6%)	4 (8%)	2 (2%)	50 (100%)

DISCUSSION

Segmental anatomy of liver given by a French surgeon Claude Couinaud remains one of the most widely accepted anatomical classification of liver which divides the liver into eight functional segments based on distribution of hepatic vessels and bile ducts. These segments are numbered consecutively starting from caudate lobe as segment one and progressing in a clockwise manner.[1] Liver is divided into two hemi-livers by a line known as Cantlie's line which marks the direction of inferior vena-cava.[13] In the left hemi-liver, the umbilical fissure marks the division of segment II and III from segment IV.[1] Segment IV of the liver borders right hemi-liver and is unlike any other segments in the left hemi-liver.[14] According to Michels Segment IV of left hemi-liver is supplied by Middle Hepatic Artery (MHA).[2] Very few literatures have mentioned the prevalence and surgical importance of MHA, and there remains a gap in anatomical description about MHA in books and surgical atlas. Unlike Michels, a study by Wang et al. suggests MHA as a Hilar artery based on the embryonic origin of hepatic arterial system, which does support the anatomical feature of MHA and cause for its variation.[3] Embryologically, Liver is supplied by three arteries, the embryonic Left Hepatic Artery (LHA), the embryonic Middle Hepatic Artery (MHA) and the embryonic Right Hepatic Artery (RHA).[1] Embryonic LHA is originated from the Left Gastric Artery (LGA), RHA from the Superior Mesenteric Artery (SMA) and MHA from the Common Hepatic Artery (CHA). This explains the presence of replaced and accessory hepatic arteries (r RHA, a RHA, r LHA, a LHA) as the remnants of embryonic hepatic arterial system.[1, 15] MHA is a Hilar artery as it is embryologically originated from the CHA and is a significant vessel in dissection of the hepatic hilum.[1] Variations of MHA further supports its embryonic origin from CHA as there were no instances of origin of MHA from replaced or accessory hepatic arteries in our study. In our study the prevalence of MHA was 76%, which is similar to the prior studies done

by Alghamdi et al. and Wang et al. that states the prevalence of MHA in there study as 79% and 71% respectively.[3, 14] Unlike Healey et al. and Futura et al. where MHA arose equally from LHA and RHA, our study points 34% of MHA originating from the RHA and 24% of MHA originating from the LHA.[16, 17] Thus, our study suggests that MHA predominantly originates from the RHA which is in accordance to the studies done by Wang et al., Kamel et al. and Jin et al. which suggests that MHA originates from the RHA in 58.3%, 62.5% and 53.2% of cases respectively.[3, 18, 19]

Greater than 2 million people each year die of liver pathologies across the globe, out of which a million of deaths are a result of hepatic cirrhosis and the other million due to viral hepatitis and hepatocellular carcinoma. Pathologies of liver accounts for 3.5% of all deaths globally. Liver cirrhosis is 11th most common cause of death and hepatocellular carcinoma is 16th most common cause of death globally.[20] Liver transplantation has been preferred treatment for adult patients with end-stage liver disease; the unavailability of cadaveric donors and poor cadaveric procurement has led Living Donor Liver Transplantation (LDLT) the preferred approach.[21] Any damages to hepatic arterial system during LDLT can cause hepatic artery thrombosis which may bring around consequences such as graft loss for recipients or infarction of remaining liver in donors or both.[7] Among all the arteries the artery supplying the segment IV of left hemi-liver has the greatest propensity of causing complications like hepatic artery thrombosis due to its anatomical position and possible variations.[8] It is very important for any surgeon to identify MHA and its pattern whenever intending to perform a hepatic resection as accidental damages to MHA can be catastrophic. In cases of MHA originating from RHA during LDLT, in left lobe allograft there will be vascular disconnection to the segment IV leading to possible graft loss and HAT.[6, 7, 8] On the other hand, right lobe graft may lead to regenerative problems and reduction in the functional volume of remnant liver in donors.[4, 5] Ischemic Cholangiopathy and biliary leakage can be witnessed in both cases since, bile ducts of segment IV is invariably supplied by MHA.[11, 12] In cases of MHA originating from the LHA, Right lobe donations are relatively safe for the donors with very less possibility of graft loss, considering there is no vascular compromise to the remnant liver.[22, 23] Further, rRHA also favors right lobe allograft as in such instances MHA if present originates from LHA. Similarly, during hepatectomy right lobe resection can lead to regenerative problems and reduction in functional volume of remnant liver when MHA originates from RHA.[4] Even in case of hepatectomy, similar to LDLT, rLHA makes hepatic resections in both left and the right lobe unfavorable. At all instances where there are possibilities of vascular compromise, there is a need of meticulous planning and operative precision along with micro-vascular anastomosis and vascular reconstruction to ensure proper hepatic perfusion and significant efforts are required in prevention of Hepatic arterial thrombosis (HAT).[24, 25, 26]

CONCLUSIONS

MHA supplying segment IV is present in nearly 70% of cases, and shows variations with regard to its anatomical origin. During liver resection and liver transplantation, preservation of vascular supply to segment IV is extremely important. It is necessary to establish the delineation of MHA origin before proceeding to surgery. A detail anatomical knowledge of MHA provides a guidance for liver resections and prevent catastrophic outcomes.

Conflict of interest: None

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