

Variations in the Origin of Middle Hepatic Artery in Living Liver Donors using CT Angiography in South Indian Population: A Retrospective Study

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ABSTRACT

Introduction: The middle hepatic artery is an artery which supplies blood to the fourth segment of the liver. Most commonly, it originates from the right hepatic artery. Injury to the middle hepatic artery during liver transplant surgeries may lead to ischaemia and also may lead to life threatening conditions like hepatic artery thrombosis in donor as well as recipient. The variations in the origin of the middle hepatic artery in the living donors were focused in the present study as it has surgical importance in the liver transplantations.

Aim: To find out the incidence of the variations in the origin of the middle hepatic artery in living liver donors using Computed Tomography (CT) angiography.

Materials and Methods: This was a retrospective observational study conducted from August 2018 to October 2021 in the Department of Anatomy, Deccan College of Medical Sciences, Hyderabad, Telangana, India. The images of CT angiographies

of 100 living liver donors were collected from the Department of Radiology, Global Hospital, Hyderabad, Telangana, India. All the CT angiographs of the living liver donors were observed for any variations in the origin of the middle hepatic artery and recorded and the percentage of each variation was calculated.

Results: Out of 100 CT angiographs studied, the incidence of the origin of middle hepatic artery was reported as 55% from right hepatic artery, 34% from the left hepatic artery, 5% from replaced left hepatic artery, 2% from the hepatic artery proper, 1% from the common hepatic artery, 1% from left gastric artery. Double middle hepatic arteries were observed in 1% of cases. Accessory middle hepatic artery was observed in 1% cases.

Conclusion: To increase the success rate of liver transplantations, the clear knowledge on the possible variations of the middle hepatic artery is needed. The variations of the middle hepatic artery reported in this study are rare and will be useful for the liver transplant surgeons.

Keywords: Computed tomography, Hepatic artery thrombosis, Hepatocellular carcinoma, Liver transplantation

INTRODUCTION

Liver diseases such as hepatocellular carcinoma and cirrhosis are the leading cause of deaths worldwide [1]. The liver cirrhosis is a condition where there is a progressive fibrosis of the liver along with distortion of the liver architecture. Hepatocellular carcinoma is reported as the 3rd most common cancer causing death and 5th most common cancer globally. It occurs with a background of liver chirrrosis [2,3]. The incidence of hepatocellular carcinoma in Indian men ranges from 0.7-7.5 and in women 0.2-2.2 per million population per year. Literature shows the incidence of hepatocellular carcinoma in cirrhotics in India is reported as 1.6% [4]. Cirrhosis of the liver progresses to end stage liver disease and the liver transplantation is the only treatment option for both, cirrhosis and hepatocellular carcinoma [5].

In the liver transplantation surgeries, the liver can be received from the cadaver or the living donors. In case of the living donor liver transplantation, the hepatic arterial system of the liver must be observed by CT angiogram to avoid or minimise intraoperative and postoperative complications. The middle hepatic artery is an artery which supplies to fourth hepatic segment and most commonly it originates from the right hepatic artery. While performing living donor liver transplantation surgeries, there is an increased risk of injuries to the middle hepatic artery which may cause reduced functional volume of the left lobe of the liver followed by ischaemia to the bile ducts of this lobe. The most common complications of the arterial injuries in the living donor liver transplant are insufficient hepatic volume, ischaemic cholangiopathy, and hepatic artery thrombosis usually observed

in the right hepatic lobe of the donor or the left hepatic lobe of the recipient. The hepatic artery thrombosis may cause graft loss in the recipient or may also cause significant decrease in the blood supply to the donor and the recipient [6,7]. Studies on the variations in the origin of the middle hepatic artery and arterial supply to the segment four of the liver were carried out in Chinese, Korean and Indian population on cadavers and CT angiograms of abdomen [8-11]. But CT angiographic studies on the variations of the middle hepatic artery in living liver donor were not much available in the south Indian population. Holbert BL et al., reported that the fourth segment is at a greater risk of undergoing hepatic artery thrombosis in postoperative phase. As per Michels NA, the fourth segment of the liver is supplied by the middle hepatic artery [12,13]. Thus, the detailed knowledge about the origin of the middle hepatic artery must be evaluated by CT angiography to consider for the prevention or reconstruction of the middle hepatic artery. Hence, the present study was undertaken to find out the variations in the origin of the middle hepatic artery.

MATERIALS AND METHODS

The present study was a retrospective study conducted from August 2018 to February 2021 in the Department of Anatomy, Deccan College of Medical Sciences, Hyderabad, Telangana, India. The analysis of the study was done from February 2021 to October 2021. The study was permitted by the Institutional Review Board (IRB No: 2018/23/015) Hyderabad.

Inclusion criteria: A total of 100 CT angiograms of adult healthy living liver donors were included in the study irrespective of gender.

Exclusion criteria: The CT angiograms of the patients with a history of abdominal surgeries, pathological conditions of the abdomen, thrombosis of hepatica arteries were excluded from the study.

The images of the CT angiograms were studied carefully observing celiac trunk, common hepatica artery, hepatic artery proper, gastroduodenal artery, right and left hepatic arteries, left gastric artery, replaced right and left hepatic arteries to find out the variations in the origins of the middle hepatic artery and the observations were recorded. The variations were classified based on the classification of Wang S et al., [8].

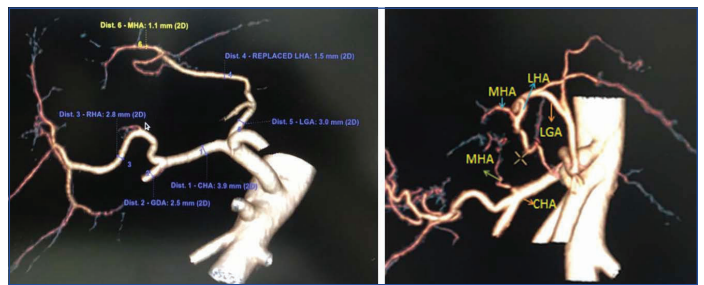
STATISTICAL ANALYSIS

The percentage of the variations observed was calculated and the incidence was reported in terms of frequency and percentages.

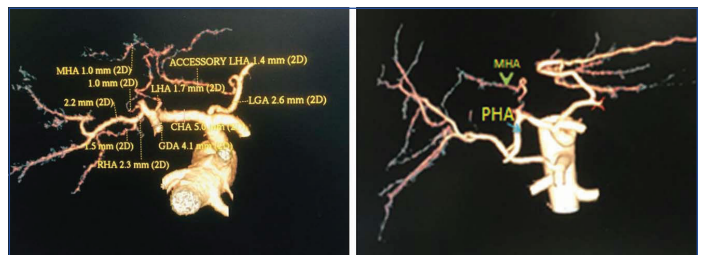
RESULTS

Among the total, 63 belonged to female and 37 belonged to male. The average age of the female and male donors was 35.36±8.92 and 30.31±11.41 years, respectively. The age ranges from 18-56 years in both. Total eight types of variations were observed in the origin of the middle hepatic artery. The variations of the middle hepatic artery were observed as follows [Table/Fig-1]; Out of 100 CT angiograms, 55 (55%) cases showed the origin of the middle hepatic artery from the right hepatic artery [Table/Fig-2]. In 34 cases (34%) middle hepatic artery was originated from the left hepatic artery [Table/Fig-3]. In 5 (5%) cases the replaced left hepatic artery originated from the left gastric artery and the middle hepatic artery originated from this replaced left hepatic artery [Table/Fig-4]. In 1 (1%) case double middle hepatic arteries was observed, one from the left gastric artery and another from the common hepatic artery [Table/Fig-5]. In 1 (1%) case an accessory middle hepatic artery was observed which was originated from the left gastric artery along with an accessory left hepatic artery from the left gastric artery [Table/Fig-6]. In 2 (2%) cases middle hepatic artery originated from the hepatic artery proper in this case the right hepatic artery originated from the superior mesenteric artery and the left hepatic artery originated from the left gastric artery [Table/Fig-7]. In 1 (1%) case the middle and the left hepatic arteries both originated from the left gastric artery [Table/Fig-8]. In 1 (1%) case the common hepatic artery terminated by giving rise to 4 branches; gastroduodenal

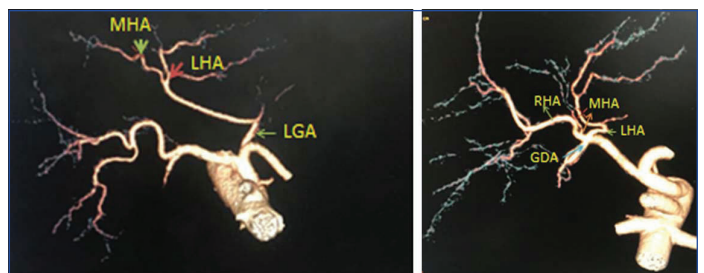
artery, left hepatic artery, right hepatic artery and middle hepatic artery [Table/Fig-9].



[Table/Fig-4]: Replaced left hepatic artery from left gastric artery and middle hepatic artery from replaced left hepatic artery.
[Table/Fig-5]: Double middle hepatic arteries; one from the left gastric artery and another from the common hepatic artery. (Images from left to right)
 MHA: Middle hepatic artery; LHA: Left hepatic artery; RHA: Right hepatic artery; LGA: Left gastric artery; CHA: Common hepatic artery; GDA: Gastro duodenal artery



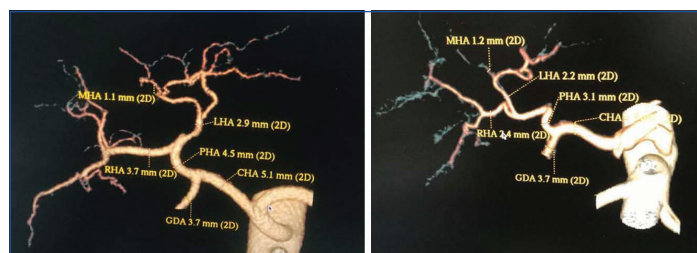
[Table/Fig-6]: Accessory middle hepatic artery from the left gastric artery along with accessory left hepatic artery from left gastric artery.
[Table/Fig-7]: The middle hepatic artery originated from the hepatic artery proper. (Images from left to right)
 MHA: Middle hepatic artery; LHA: Left hepatic artery; RHA: Right hepatic artery; CHA: Common hepatic artery; GDA: Gastro duodenal artery; LGA: Left gastric artery; PHA:



[Table/Fig-8]: The middle and the left hepatic arteries originated from the left gastric artery. **[Table/Fig-9]:** Common hepatic artery gives gastroduodenal artery, left hepatic artery, right hepatic artery and middle hepatic artery. (Images from left to right)
 MHA: Middle hepatic artery; LHA: Left hepatic artery; RHA: Right hepatic artery; GDA: Gastro duodenal artery; LGA: Left gastric artery

Origin of middle hepatic artery	Percentage (%)
Right hepatic artery	55
Left hepatic artery	34
Replaced left hepatic artery	05
Hepatic proper artery	02
Common hepatic artery	01
Double middle hepatic artery (1 from common hepatic artery and another from left gastric artery)	01
Left gastric artery	01
Accessory middle hepatic from left gastric artery	01

[Table/Fig-1]: Showing the incidence of variations in the origin of middle hepatic artery.



[Table/Fig-2]: The middle hepatic artery from the right hepatic artery.
[Table/Fig-3]: The middle hepatic artery from the left hepatic artery. (Image from left to right)
 MHA: Middle hepatic artery; LHA: Left hepatic artery; RHA: Right hepatic artery; CHA: Common hepatic artery; GDA: Gastro duodenal artery; PHA: Proper hepatic artery

DISCUSSION

The advanced stage of the liver cirrhosis and the hepatocellular carcinoma are the end stage liver diseases. The best treatment option for the end stage liver disease is the liver transplantation. The cadaveric liver donors are not frequently available, so the living donor liver transplantation is adopted [14].

The middle hepatic artery is not mentioned and neglected in most of the anatomy textbooks. It is an artery which supplies to fourth segment of the liver. The blood supply to the liver was first described by Healey JE et al., and the name middle hepatic artery which supplies to the fourth segment of the liver was proposed by Michels NA [13,15]. Putta T et al., reported that the segment four was predominantly supplied by a branch from the left hepatic artery followed by right hepatic artery which is contrary with the present study [11]. The incidence of origin of middle hepatic artery from the common hepatic artery was similar with the findings of Wang S et al., when compared with the present study [8]. Jin GY et al., reported higher incidence of origin of middle hepatic artery from Proper Hepatic Artery (PHA) compared to the present study [Table/Fig-10] [8-10]. Double and accessory middle hepatic arteries were reported in the present study were rarely reported in the literature [11].

Author	RHA	LHA	PHA	CHA
Jin GY et al., (2008) [9]	53.2%	32.3%	4.8%	-
Wang S et al., (2010) [8]	58.3%	36.9%	2.9%	1.9%
Ghosh SK (2014) [10]	52.8%	47.2%	-	-
Present study (2022)	55%	34%	2%	2% (1 Accessory, 1 common)

[Table/Fig-10]: Showing the comparison of the incidence of the variations in the origins of MHA [8-10].

RHA: Right hepatic artery; LHA: Left hepatic artery; PHA: ; CHA: Common hepatic artery

In live donor liver transplantation cases, presence of replaced right hepatic artery is favourable, as in these cases the middle hepatic artery arises from the left hepatic artery. Whereas presence of replaced left hepatic artery is not favourable in both lobes of the liver as the middle hepatic artery if present, it commonly arises from the right hepatic artery in these cases [8]. Harada N et al., reported in their study that, in living donor liver transplantation, the middle and left hepatic artery reconstruction is recommended and also safe to prevent biliary stricture caused by dual hepatic artery reconstruction especially when the graft has left and middle hepatic artery stumps. So, the variations in the origin of the middle hepatic artery must be assessed preoperatively when the transplant surgeon plans for the reconstruction of the middle hepatic artery [16]. In live donor liver transplantation, reconstruction of the arteries to the remaining part of the liver is very much essential to avoid postoperative complications. So, preoperative identification of the variations of the middle hepatic artery need to be considered to avoid unnecessary extensive dissection at the hilum of the liver and also minimises the damage to the liver parenchyma and bile ducts [17,18].

Limitation(s)

The present study was limited to study the variations in the origin of middle hepatic artery in living liver donors in single centre. Further multicentric studies can be carried out in large population.

CONCLUSION(S)

The proper knowledge on the variations of the middle hepatic artery is very much necessary for the surgeons who deal with live donor liver transplantation, to minimise the damage to the hepatic tissue and bile ducts and also will help in arterial reconstruction. The

variations reported in this study will be useful for the liver transplant surgeons to achieve the higher success rate.

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