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Original Research Article

EXTRA-HEPATIC BRANCHING PATTERN OF COMMON HEPATIC ARTERY AND ITS VARIATIONS: A HUMAN CADAVERIC STUDY

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ABSTRACT

Background and objective: The hepatic arterial anatomy is variable. Pre-operative evaluation of extra-hepatic arterial pattern is relevant for the surgeons during hepatic surgery as well as for the radiologists while doing different procedures. The main purpose of the study was to identify the normal & variable branching pattern of common hepatic artery.

Materials and Methods: Extra-hepatic arterial pattern was observed in 45 adult cadavers (male & female) by in situ dissection. The point of origin & branching pattern of common hepatic artery (CHA) till the porta hepatis were observed and also looked for presence of aberrant/accessory hepatic arteries. The branching pattern of hepatic artery before entering the liver was photographed.

Results: Normal extra-hepatic arterial pattern was found in 46.67% livers. The variable branching patterns was seen in the remaining livers (53.3%). The common variations were: presence of accessory left hepatic artery (LHA) from left gastric artery (LGA) (20%), trifurcation of common hepatic artery (CHA) into gastro-duodenal artery (GDA), right hepatic artery (RHA) & left hepatic artery (LHA) (13.33%), origin of right gastric artery (RGA) from left hepatic artery (LHA) (13.33%). Some rare variations were also observed.

Conclusion: The knowledge of extra-hepatic arterial anatomy is important in the field of hepatic surgery especially during split & living donor liver transplantations. It will help to reduce the post-operative complications such as hepatic necrosis and bleeding during surgery.

KEY WORDS: Common Hepatic artery, aberrant hepatic artery, liver transplantation.

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BACKGROUND

Liver is the second largest organ of human body occupying the right hypochondrium of abdominal cavity. The usual arterial supply of liver is common hepatic artery arising from celiac trunk. Coeliac trunk (CT) is a ventral branch of abdominal aorta which trifurcates into left gastric (LGA), splenic (SA) & Common hepatic arteries (CHA). Common hepatic artery is the largest branch of coeliac trunk in foetal & postnatal life, but in adults it is intermediate in size. It gives right gastric (RGA) & gastro-duodenal branches (GDA). After its origin from coeliac trunk, it courses antero-laterally below the epiploic foramen superior to the first part of the duodenum. The hepatic artery is subdivided into common hepatic artery (CHA) (from coeliac trunk to point of origin of gastro-duodenal artery) & hepatic artery proper (PHA) (from the point of origin of gastro-duodenal artery to its bifurcation) (Fig.1). Then the proper hepatic artery ascends between the layers of right free border of lesser omentum anterior to portal vein & to the left of common bile duct. Before entering into liver parenchyma it divides into right & left hepatic arteries at porta hepatis.

The patterns of arterial supply are not constant. In variant patterns, the liver receives arterial flow through branches coming from superior mesenteric artery, left gastric artery, or, rarely from other arterial trunks [1]. In 1966, Michel [2] classified the vascular anatomy of variation into 10 types which was again modified by Hiatt [3] et al. into 6 types.

Variations in arterial pattern of supply to the liver should be known to surgeons specialised in hepato-biliary-pancreatic area and radiologists during their intervention procedures like chemoembolisation etc [1].

Hence, this study attempts to observe the extra-hepatic vascular branching patterns.

AIMS AND OBJECTIVES

To study

a) The variation in the origin of common hepatic artery.

b) The variation in the branching pattern of common hepatic artery from the coeliac trunk to the porta hepatis.

c) The variation in the branches of Common hepatic artery.

MATERIALS AND METHODS

During routine dissection, 45 formalin embalmed adult human cadavers (34 male and 11 female, 45-70 years of age) with liver in situ were dissected to observe the extra-hepatic arterial pattern in the department of Anatomy of M.S. Ramaiah Medical College, B.R. Ambedkar Medical College, Bangalore Medical College, Sapthagiri Institute of Medical Science, Kempegowda Institute of Medical Science, Bangalore. Distorted and diseased bodies were excluded.

Standard median vertical incision (extending from xiphi sternum to upper border of pubic symphysis) was given in the anterior abdominal wall. Superficial fascia, muscles and peritoneum were reflected to expose the abdominal aorta & its branches. Further dissection was done to expose the liver. The coeliac trunk was dissected and looked for the origin & branching pattern of common hepatic artery. The common hepatic artery was traced till the porta hepatis and any variations with respect to its origin, branches and presence of aberrant/accessory branches were noted. The findings were photographed using HD Digital Sony camera (16 megapixel).

RESULTS

In the present study, totally 15 types of branching patterns of the extra hepatic arterial system was observed. (Table 1)

Table 1: showing the variation in the origin of common hepatic artery and associated branches.

SL. NO.	PATTERNS	PERCENTAGE (%) (TOTAL SPECIMEN 45)
1	CHA arising from CT divides into GDA & PHA. PHA subdivides into RHA & LHA	46.67% (21)
2	Presence of accessory LHA arising from LGA	20% (9)
3	Trifurcation of CHA into GDA, RHA & LHA	13.33% (6)
4	Presence of RGA from LHA	13.33% (6)
5	Presence of RGA from RHA	4.44% (2)
6	Trifurcation of CHA+RGA from LHA	4.44% (2)
7	Presence of replaced(aberrant)(aberrant)(aberrant) LHA arising from LGA.	2.22% (1)
8	Presence of accessory LHA from LGA + replaced(aberrant)(aberrant)(aberrant) RHA from GDA+ RGA from LHA	2.22% (1)
9	Quadrification of CHA into-GDA, RGA, RHA & LHA	2.22% (1)
10	Quadrification of CHA into GDA, RHA, LHA & CA + RGA from LHA	2.22% (1)
11	Presence of accessory LHA from GDA	2.22% (1)
12	Presence of PSPDA from CHA	2.22% (1)
13	Presence of accessory LGA from PHA	2.22% (1)
14	Trifurcation of CHA+RGA from RHA	2.22% (1)
15	Accessory LHA from LGA +RGA from LHA	2.22% (1)

Out of the 10 Michel's hepatic arterial variations [2], 3 were seen in the present study. Type I was most common, seen in 21(46.7%) livers. Type V was seen in 9(20%) and Type II in 1(2.22%) livers. Hence, in the present study, 12 types of other variations were found which are not included in Michel's classification of variation. Most common were trifurcation of CHA into GDA, RHA & LHA in 6 (13.33%) livers and origin of RGA from LHA in 6(13.33%) livers.

Table 2: Non-hepatic branches from hepatic artery.

SL. NO.	VARIATIONS	SPECIMENS
1	**Presence of RGA from LHA**	**6(13.33%)**
2	Presence of RGA from RHA	2(4.44%)
3	Presence of PSPDA from CHA	1(2.22%)
4	Presence of accessory LGA from PHA	1(2.22%)

Fig. 1: Extra-hepatic arterial anatomy.

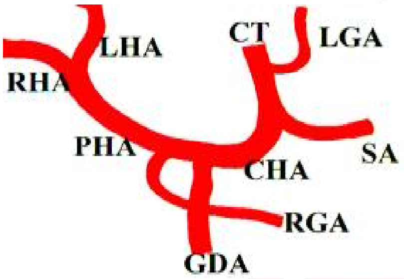


Fig. 2: Normal Common Hepatic artery branching pattern.

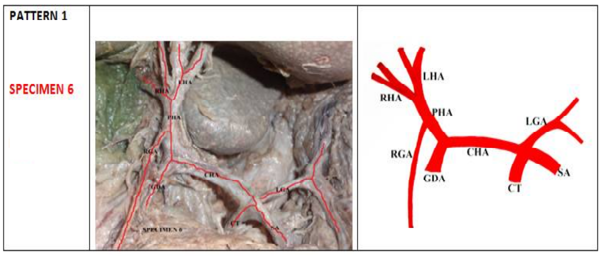


Fig. 3: Presence of accessory LHA arising from LGA.

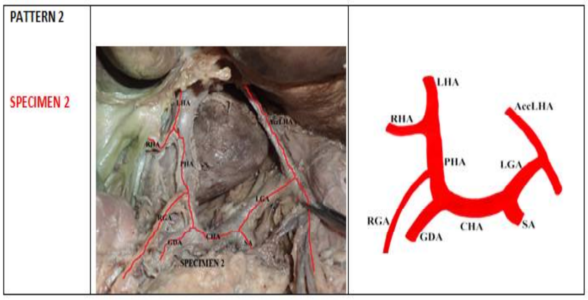


Fig. 4: Trifurcation of CHA into GDA, RHA & LHA.

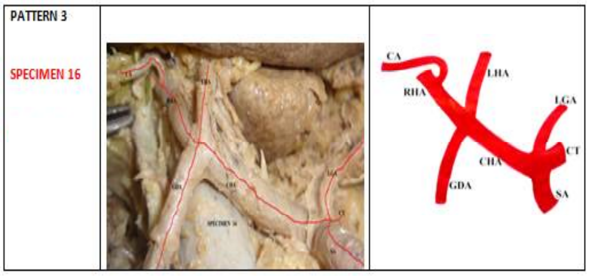


Fig. 5: Presence of RGA from LHA.

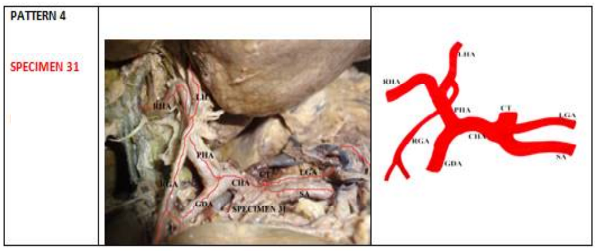


Table 3: Hepatic branches from non-hepatic origin.

SL. NO.	VARIATIONS	SPECIMENS
1	**An accessory left hepatic artery arises from left gastric artery**	**9(20%)**
2	A replaced(aberrant) left hepatic artery arises from left gastric artery	1(2.22%)
3	Presence of accessory LHA from GDA	1(2.22%)
4	Replaced(aberrant) RHA from GDA	1(2.22%)

Fig. 6: Presence of RGA from RHA.

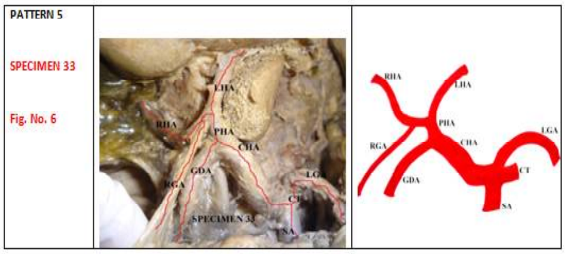


Fig. 7: Trifurcation of CHA+RGA from LHA.

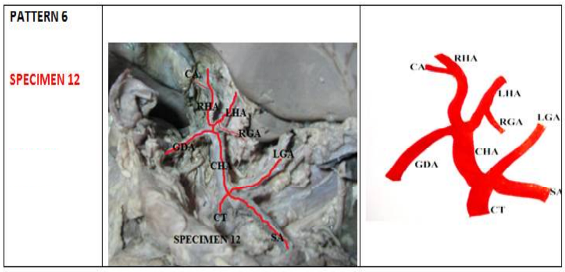


Fig. 8: Presence of replaced(aberrant) LHA arising from LGA.

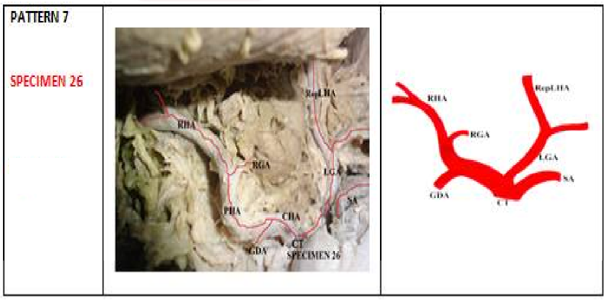


Fig.9: Presence of accessory LHA from LGA + replaced (aberrant) RHA from GDA+ RGA. from LHA.

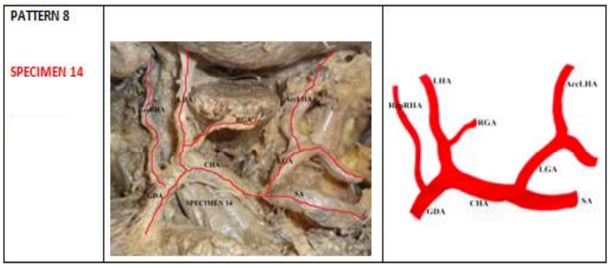


Fig.10: Quadrification of CHA into-GDA, RGA, RHA & LHA.

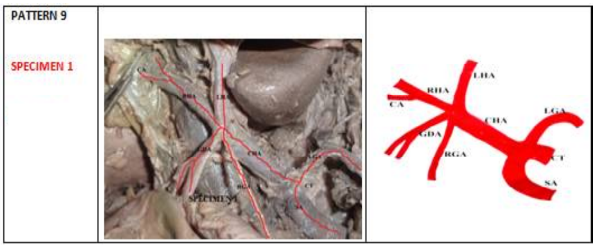


Fig. 11: Quadrification of CHA into GDA, RHA, LHA & CA + RGA from LHA.

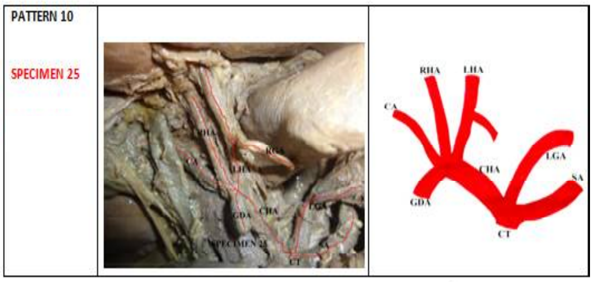


Fig. 12: Presence of accessory LHA from GDA.

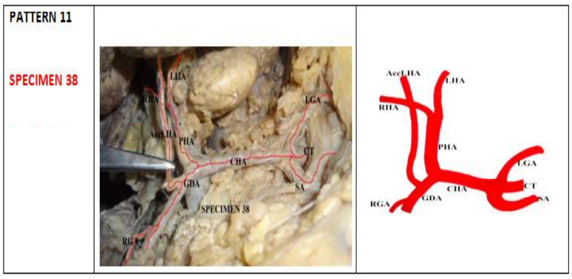


Fig. 13: Presence of PSPDA from CHA.

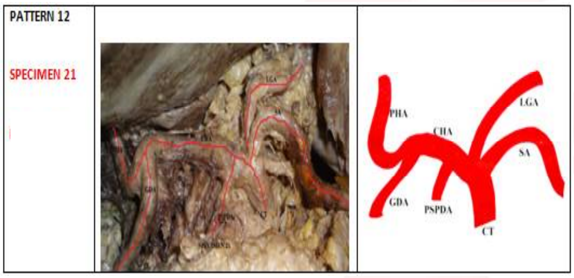


Fig. 14: Presence of accessory LGA from PHA.

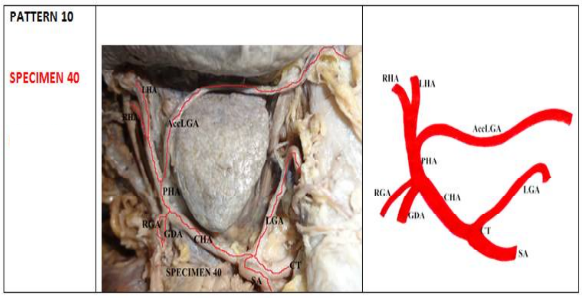
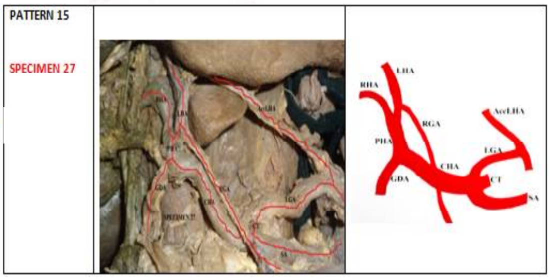


Fig. 15: Trifurcation of CHA+RGA from RHA.

Fig. 16: Accessory LHA from LGA +RGA from LHA.



DISCUSSION

In the present study, normal hepatic arter pattern was observed in 46.7% livers. Arterial variants were found in rest (53.3%) of the livers.

Origin of common hepatic artery: There were no variations with respect to origin of CHA in the present study. The origin of CHA was found to be always from the coeliac trunk. Other studies show variant origins of CHA. Song et al. have studied the coelic axis and CHA patterns by Spiral CT and DSA and found variant origin of CHA. Their study demonstrated 96.4% of CHA arising from Coeliac trunk, 0.16% arising from LGA, 2.9% from SMA and 0.04% directly from Aorta [9].

CHA variants: The CHA variant patterns were seen in 53.3% of livers in the present study. Michel, Rafael, Hiatt et.al, Lavelle et.al, Abdullah et.al, Ahmed et.al, have shown 45%, 30%, 24.3%, 33.2%, 31.9%, 33% variations in CHA patterns in their studies [3,7,8,10,18,19,21]. Variations in the extra-hepatic arterial pattern were observed to be more in the present study than the above mentioned studies.

In 1966, Michel classified the extra-hepatic arterial anatomy into 10 different types on the basis of autopsy of 200 cadavers. Many cadaveric studies on extra-hepatic arterial pattern have been classified as per Michel's classification. Table No. 4 compares various studies including the present study based on Michel's classification. The most common arterial variation noted in Michel's and other studies [3,7,8,10,18,19,21], was Type III (which was origin of replaced (aberrant) HA from superior mesenteric artery), Type II (presence of replaced(aberrant) LHA originating from LGA) & Type VI (accessory right hepatic artery arising from superior mesenteric artery) respectively (table no.4). In the present study, the most commonly observed variation was Type V pattern which was origin of accessory LHA from LGA (20% livers). The other types of Michel's classification (Type III, IV, VI, VII, VIII, IX & X) were not found in the present study. In comparison to other studies and Michel's

Table 4: Comparison of various arterial patterns following michel's description.

Michel's description	Michel [2] 200(%)	Rafael et.al. [7] 1081(%)	Hiatt et.al. [3] 1000(%)	Lavelle et.al. [8] 202(%)	Abdullah et.al. [10] 932(%)	Sehgal et.al. [18] 50(%)	Ahmed et.al. [19] 1000(%)	Sureka et.al. [21] 600(%)	Present study 45(%)
TYPE I	55%	70%	75.70%	66.80%	68.10%	0%	67%	0%	46.70%
TYPE II	**10%**	**9.70%**	**9.70%**	7.40%	8.10%	4.17%	**17%**	10.80%	**2.22%**
TYPE III	**11%**	7.80%	**10.60%**	**11.40%**	**10.20%**	**11.62%**	3.40%	**15.16%**	0%
TYPE IV	1%	3.10%	2.30%	0.50%	0%	0%	1.30%	0%	0%
TYPE V	8%	3.90%	9.70%	7.40%	8.10%	4%	2.50%	7.60%	**20%**
TYPE VI	7%	0.60%	**10.60%**	0%	**10.20%**	8%	1.10%	5.15%	0%
TYPE VII	1%	0.60%	0%	0%	6.40%	0%	0.10%	0%	0%
TYPE VIII	2%	0.30%	0%	0%	0%	0%	0.60%	0%	0%
TYPE IX	2.50%	2.50%	1.50%	1.50%	1.60%	0%	0.90%	1%	0%
TYPE X	0.50%	0%	0%	0.50%	0%	0%	0%	0%	0%

classification, the present study showed a different arterial pattern (Type V) to be more common. The type II variety of Michel's classification was observed to be the next common variation in the present study in 2.22% livers.

The difference in occurrence of most common pattern of arterial variation could be due to racial difference. The studies mentioned in the table no. 4 were done mostly in European[3], Pakistani [19] & French [10] population etc. But in the present study, the subjects belonged to the Indian population.

The other reason for difference could also be the sample size; most of the studies compared in table no. 4 have sample size of 200 and above. If the sample size of the present study was more, then the other variations noted by Michel could have been observed.

The type V variation is clinically significant in liver transplantation. During transplantation, accessory left hepatic artery has to be ligated close to its origin from left gastric artery in the donors having this variant pattern. When this liver from the donors with type V variant is reconstructed in recipient, surgeons should be aware that accessory LHA also should be anastomosed because accessory LHA will be supplying the segment II & III lobes of liver.

Type II variation (presence of replaced (aberrant) LHA arising from LGA): Besides the Type V pattern, the Type II pattern was found in 2.22% livers in the present study which was origin of replaced(aberrant) LHA from LGA. The incidence of this variation is less in the present study compared to previous studies and it could be due to less sample size. In the table no.4, it can be observed that the studies [2,3,7,19] having more sample size (200,1000,1081 etc.) showed higher incidence of occurrence of type II variation. Sehgal et.al. [18] mentioned a similar kind of percentage like the present study i.e the less incidence (4.17%) of occurrence of type II variation because the sample size was less (50) as compared to other studies [2,3,7,19]. Hence, an increase in sample size would increase the incidence of variation.

The presence of aberrant (replaced) or accessory LHA is important in the recipient (to make anastomotic channel) as well as in the donor (while ligation of LHA) during liver transplantation.

Post-transplantation hepatic arterial complications like stenosis & thrombosis can be due to small calibre of CHA. The small caliber of CHA is likely in the presence of replaced(aberrant) hepatic artery variation. The calibre of CHA is usually normal in the cases of accessory hepatic artery. Hence, the risk of the above mentioned complications due to small calibered CHA is more seen in the cases of completely replaced (aberrant) hepatic artery than in those with accessory hepatic artery [21]. Proper pre-operative evaluation of hepatic arterial pattern in these individuals will help to reduce such complications.

The present study demonstrated many variations which have not been described in Michel's classification. Such variations have been described in table No. 1 and Fig. No. 2-16. Among these variations, presence of trifurcation of CHA into GDA, RHA & LHA and origin of RGA from LHA were most common (13.33% livers).

CHA related anomalies: Among the anomalies which are not mentioned by Michel's classification, CHA related anomalies were most common. The most common obervations were trifurcation and quadrification of CHA which are discussed further.

Trifurcation of CHA: Normally, the CHA gives off the GDA and continues as PHA. The PHA then divides into RHA and LHA to supply the liver. In certain arterial pattern, the CHA divides into the RHA, LHA and GDA with the absence of PHA. This variation is described as trifurcation of CHA. When trifuraction of CHA was compared with other studies, the percentage of its incidence was lower around 2.3% [10] and 7.16% [21] as compared to 13.3% of the present study. This could be due to differences in study sample. Abdullah et al. [10] used the French population as study sample and Sureka et al. [21] did in North Indian population. The present study was done on South Indian population.

The variant trifurcation of CHA was found to be associated with other extra-hepatic arterial variations. In two livers (SPECIMEN NO. 3 & 12) (Fig.No.7), the trifurcation of CHA was found along with RGA arising from LHA. Another liver (SPECIMEN NO.4) (Fig.No.15) showed RGA arising from RHA in addition to the trifurcation of CHA. Hence 50% of trifurcation of CHA can be associated RGA arising either from RHA or LHA.

The anatomical variations of hepatic artery especially like trifurcation of common hepatic artery as found in the present study are important in recent oncologic interventional procedures like trans-catheter arterial chemoembolization, trans-arterial radionuclide therapy and placement of infusion pumps. Surgical placement of catheter is done usually in the GDA with the tip in the proximal GDA or in PHA perfusing RHA & LHA in an individual with normal hepatic arterial pattern. Hence, an alternate catheter position or placement of more than one catheter is required to ensure adequate tumour perfusion in cases with above mentioned variation [21].

During surgery, the surgeons should be aware that the anomalies of CHA can be associated with RGA anomalies because ligation of CHA in such patients can compromise the blood supply to stomach. But this might not be serious due to the arterial anastomosis of RGA with LGA.

During hepatectomy, in patients with trifurcation of CHA, ligation of CHA (which is normally done during hepatectomy) can compromise the blood supply to stomach & duodenum leading to gastric and duodenal hypo-perfusion [16]**.** Hence this variant arterial pattern becomes relevant in liver surgerie.

Quadrification of CHA: Abdullah et al. [10] mentioned the quadrification of CHA into RHA, LHA, GDA & RGA in one case as rare variation. Sureka et al [21] also showed the quadrification of CHA into RHA, LHA, GDA & MHA in 2.16% cases.. In the present study, two kinds of Quadrification of CHA were noticed. In one specimen, the CHA divided into GDA, LHA, RHA and CA. The second pattern showed quadrification of CHA which was also associated with origin of RGA from LHA (Fig.11). The second pattern of quadrification was associated with RGA variation has not been mentioned in literature.

The Quadrification of CHA is very important during transfusion of chemotherapeutic agents through hepatic arteries due to the similar reason as mentioned with trifurcation of CHA.

So the RGA anomalies can be associated with anomalies of CHA both in trifurcation as well as in Quadrification.

Accessory LHA: In the present study, the Accessory LHA from LGA (Michel's Type V) was also found to be in association with other variations which has not been reported in literature. It was found to be in combination with presence of RGA from LHA in one liver (SPECIMEN NO. 27) and also with combination of two variations such as presence of replaced(aberrant) RHA from GDA & origin of RGA from LHA in one liver (specimen 14). In such type of cases, pre-operative evaluation of arterial anatomy is required as the level of ligation of the feeding blood vessels to the liver is dependent on these variations.

Normally, the GDA after taking origin from CHA runs downwards lying behind the second part of duodenum in close proximity with head of the pancreas. If there is a presence of replaced (aberrant) right hepatic artery arising from the GDA then care has to be taken to preserve the RHA while performing surgeries related to pancreas and duodenum. This replaced (aberrant) RHA can also be involved in tumours of head of the pancreas [19]. During surgery of malignancies of head / uncinate process of pancreas, it is difficult to identify the replaced (aberrant) RHA originating from GDA & supplying the right lobe of liver in order to preserve it. If this artery gets damaged during pancreatic surgery, it can compromise the blood supply to liver leading to hepatic necrosis [21]. Hence Surgeons should be careful and aware of the presence of replaced(aberrant) RHA during surgery of above mentioned regions not to damage the replaced(aberrant) RHA.

In the present study, the accessory LHA was also found to be originating from GDA in one liver (Specimen 38). During transplantation of left lobe of liver, this variation is significant because the accessory LHA has to be reconstructed with the feeding vessels in the recipient. This is because when there is presence of the accessory LHA, it is the source of blood supply to segment II & III. This variant is also relevant during pancreatic surgery due to the similar reason mentioned with Accessory RHA variant from GDA.

Variant origin of RGA:

Table 5: Comparison of origin of RGA.

ORIGIN of RGA	Daseler et.al. [22]	Present study
	N-250(%)	N-45(%)
1.PHA(normal)	125 (50%)	37(82.2%)
2.LHA	**81(32.4%)**	**8(13.33%)**
3.RHA	10(4%)	2(4.44%)

Daseler et.al. [22] described the normal origin of RGA was from PHA (50% livers). The most common variant origin of RGA was seen from LHA followed by RHA. The present study also showed a similar pattern in the incidence of origin RGA. So the most common variant origin of RGA is from LHA.

The variant origins of RGA are important to know during infusion of chemotherapeutic agents into the liver through the hepatic arteries in hepatic carcinoma patients. In these cases chemotherapeutic agents can affect oesophageal & gastric mucosa after passing through RGA. It is also important for the donors during liver transplantation, because ligation of LHA or RHA can lead to vascular compromise to the stomach.

Origin of Accessory of LGA: was found from proper hepatic artery only in one (2.22%) liver (specimen 40) in the present study which has been reported by Song et al [23] in 43 (20.97%) cases in Korean population. H.Nakamura et al. [24] also reported presence of accessory left gastric artery originating from left hepatic artery in 14.2% cases in Japanese. Adachi [25] also found this artery in 11.1% cases among Japanese.

Accessory left gastric artery may play an important role in malignancy of lower oesophagus and fundus of stomach as it is the main feeding artery and a tumour vessel. Chemotherapeutic agents infused into the PHA with presence of accessory LGA from it can enter into the gastric mucosa through the accessory LG artery and can lead to gastric erosion [24].

If we compare anomalies related to RGA and LGA, the RGA was mainly a replaced(aberrant) RGA taking origin from either the RHA or the LHA whereas the LGA was an accessory one along with the presence of regular LGA from Coeliac trunk. The RGA is more prone to variation than the LGA.

The extra hepatic arterial pattern variation could also be classified into variations related to hepatic artery branches originating from non-hepatic branches and variations related to non-hepatic branches arising from hepatic branches. This has been tabulated in table no. 2 and 3.

The tables 2 and 3 showed that hepatic artery branches arising from non-hepatic arteries are more common than the non-hepatic branches arising from hepatic artery branches. This could be explained based on the embryological blood supply to the liver. In early stage of embryo, there are three hepatic lobes: right lateral sector, para-median sector & left lateral sector. In embryo, there are three hepatic arteries: right hepatic artery from SMA for right lateral segment, middle hepatic artery from CHA for para-median segment and left hepatic artery LGA for left lateral segment. The right and left hepatic arteries disappear and middle hepatic artery becomes hepatic artery proper in adult [15]. If the some part of embryonic right or left hepatic artery persists, it becomes accessory or replaced (aberrant)RHA or LHA. It forms the embryologic basis of origin of hepatic branches from non-hepatic artery. . Sometimes the embryonic and foetal pattern may persist and the middle hepatic artery, in that case, supplies the quadrate and caudate lobes of the liver.

Most of the ventral segmental branches disappear except 3 arteries which give rise to CT to foregut, SMA to mid-gut & IMA to hindgut. In early stage of development, the liver is enlarged in size compared to gut. Later stage, as the size of the liver decreases, the gut increases in size because most of the embryonic hepatic arteries regress & the arteries to gut expand. Since the coeliac trunk is the artery to foregut, it can form the basis of origin of hepatic arteries from non- hepatic artery.

CONCLUSION

Extra-hepatic arterial anatomy is variable in branching pattern. The knowledge of hepatic arterial branching pattern is an important pre-requisite during surgery as well as during different interventional radiological procedures.

Among the Michel's classification, the most common extra-hepatic variation observed in the present study was type V (Origin of accessory LHA from LGA) followed by type II (replaced (aberrant)(aberrant) LHA from LGA). In addition, the present study observed 12 other different extra hepatic arterial patterns not mentioned in Michel's classification. The most common among them was trifurcation and quadrification of CHA, RGA from LHA and RGA from RHA. Some of these were coexistent. Other new variations have been documented like presence of accessory LHA from GDA, Accessory LHA from LGA associated with RGA from LHA and many multiple variations in the same specimen. There can be presence of non-hepatic branches from hepatic artery as well as hepatic branches from non-hepatic artery. This adds to the knowledge of the hepatic arterial anatomical variations which will be helpful during hepatic surgery.

These intricate details of arterial variations are of utmost interest to surgeons dealing with surgeries of the foregut derivatives. The identification of the arterial branching pattern preoperatively or preinvasively is essential for planning of the procedure and hence prevent complications.

Hence this study gives a meticulous and comprehensive data of extra-hepatic arterial variations. The limitation of our study is the small sample size. Further increasing the sample could give more varied patterns.

ABBREVIATIONS

CT- Coeliac trunk
LGA- Left Gastric artery
SA- Splenic artery
CHA- Common Hepatic artery
RGA- Right Gastric artery
GDA- Gastroduodenal artery
PHA- Proper Hepatic artery
RHA- Right hepatic artery
LHA- Left Hepatic artery
CA- Cystic artery
PSPDA- Posterosuperior Pancreatico Duodenal artery
Acc.- Accessory
Rep- Replaced(aberrant)

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REFERENCES

[1]. Braun MA, Collins MB, Wright P. An aberrant right hepatic artery from the right renal artery: anatomical vignette. Cardiovasc Intervent Radiol. 1991; 14: 349-351.

[2]. Michels NA. Newer anatomy of the liver and its variant blood supply and collateral circulation. Am J Surg. 1966; 112: 337-347.

[3]. Jonathan R.Hiatt, Joubin Gabbay, Ronald W.Busuttil. Surgical anatomy of the hepatic arteries in 1000 cases. Annals of Surgery.1994; 220(1):50-52.

[4]. Bannister L. H, Berus. M. M, Collins. P, Dyson. M, Dusek. J. E, Ferguson. M. W. J. Gray's Anatomy, 40th edition. ELBS, 2009; Chapter- liver: 1163-1173.

[5]. Keith L. Moore and T.V.N.Persaud. The Developing Human Clinically Oriented Embryology.8th edition, 2009; Chapter No 15-The digestive system: 218-220.Elsevier.

[6]. Guang Yu Jin, Hee Chul Yu, Hyung-sun Lim, Jang Il Moon,Jeong Hun Lee, Jin Wook Chung, et.al. Anatomical Variation of the Origin of the Segment 4 Hepatic artery & their clinical Implication. Liver transplantation.2008; 14: 1180-1184.

[7]. Rafael Lopez-Andujar, Angel Moya, Eva Montalva, Marina Berenguer, Manuel De Juan, Fernando San Juan, et.al. Lessons learned from anatomic variants of the hepatic artery in 1,081 transplanted livers. Liver transplantation. 2007;13:1401-1404.

[8]. Michael T. Lavelle, Vivian S. Lee, Nell M. Rofsky, Glenn A. Krinsky, Jeffrey C.Weinreb. Dynamic Contrast-enhanced Three-dimensional MR Imaging of Liver Parenchyma: Source Images & Angiographic Reconstructions to define Hepatic Arterial Anatomy.Radiology.2001; 218: 389-394.

[9]. Soon-Young Song, Jin Wook Chung, Yong Hu Yin, Hwan Jun Jae, Hyo-Cheol Kim, Ung Bae Jeon et.al. Celiac axis and common hepatic artery variations in 5002 patients: Systemic analysis with spiral CT and DSA. Vascular and Interventional Radiology. 2010; 255(1): 278-288.

[10]. Siraj Saadaldin Abdullah ,Jean-Yves Mabrut,Vincent Garbit, Eric De La Roche , Eric Olagne, Agne's Rode et al.Anatomical variations of the hepatic artery: study of 932cases in liver transplantation. Surg Radiol Anat. 2006; 28: 468–473.

[11]. Sharmila Saran Rajendran, Senthil Kumar Anbu-mani, Aruna Subramaniam, M.S.Thotakura Balaji, Hannah Sugirthabai Rajila Rajendran. Variable branching patterns of the common hepatic artery and the coeliac artery. Journal of Clinical & Diagnostic Research.2011; November (suppl-2); 5(7):1433-1436.

[12]. Debasis Bandopadhyay, Surajit Ghatak, Nivenjit Tiwari, Lalit Garg. Hepatic artery variation: a case report. International Journal of Anatomical Variations. 2012; 5: 79-80.

[13].Baker RJ, Josef E. Fischer, Mastery of Surgery, LIPPINCOTT WILLIAM & WILKINS. 4th edition, 2001; chapter- The Liver & Biliary Tract: 1047-1050.

[14]. C.D.Gupta, S.C.Gupta. Evaluation of intrahepatic arterial branching patterns in corrosion casts.J.anat.1976;122(1):31-41.

[15]. Guang Yu Jin, Hee Chul Yu, Hyung-sun Lim, Jang Il Moon,Jeong Hun Lee, Jin Wook Chung, et.al. Anatomical Variation of the Origin of the Segment 4 Hepatic artery & their clinical Implication. Liver transplantation.2008;14:1180-1184.

[16]. Dushyant Sahani, Aparna Mehta, Michel Blake, Srinivasa Prasad, Gordan Harris, Sanjay Saini. Preoperative hepatic vascular evaluation with CT and MR Angiography : implications for surgery. Radiographics. 2004; 24(5): 1367-1380.

[17]. Couinaud C. Surgical anatomy of the liver revisited: Embryology. Paris, Couinaud, 1989, pp. 11-24.

[18]. Sehgal G, Srivastava A.K, Sharma P.K, Kumar N, Singh R. Variations of extra-hepatic segments of hepatic arteries: a multislice computed angiography study. International Journal of Scientific and Research Publications. 2013; 3(2): 2250-3153.

[19]. Awaris Ahmed, Rashed Nazir, Rayyan Pervez, Umar Amin, Sadia Babar, Atif Rana. Hepatic arterial variations and its implications on hepatobiliary surgery. European Society of Radiology. 2013; 10: 1-29.

[20]. John E. Skandalakis, Lee J. Skandalakis, Panajiotis N. Skandalakis, Petros Mirilas.Hepatic surgical anatomy. Surg Clin Am. 2004; 84: 413-435.

[21]. Binit Sureka, Mahesh Kumar Mittal, Aliza Mittal, Mukul Sinha, Narendra Kumar Bhambri, Brij Bhushan Thukral. Variations of celiac axis, common hepatic artery and its branches in 600 patients. Indian Journal of Radiology and Imaging. 2013; 23(3): 223-233.

[22].Daseler, E.H. Anson, B.J., Hambley, W.C., A.F.Reimamm. The cystic artery & constituents of the hepatic pedicle-a study of 500 specimens. Surg, Gynaecol & Obstet. 1947; 85: 47-63.

[23]. Song SY, Chung JW, Lim HG,Park JH. Nonhepatic arteries originating from the hepatic arteries: angiographic analysis in 250 patients. J Vasc Interv Radiol. 2006 March; 17(3):461-9.

[24]. H.Nakamura, H. Uchida, C.Kuroda, H. Yoshioka, K. Tokunaga, T. Kitatani et.al. Accessory left gastric artery arising from left hepatic artery: angiographic study. American Journal of Roentgenology.1980; 134(3): 529-532.

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