An Integrated Autopsy based Study on Variations in Origin of Right and Left Hepatic Arteries & Cystic Artery in Light of Hepato-Biliary Surgery

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Abstract

Background: Laparoscopic Cholecystectomy is widely accepted as the gold standard in the treatment of cholelithiasis and this new technique was initially associated with a significant increase in morbidity, and in particular, in iatrogenic biliary injury and arterial haemorrhage, perhaps due to a lack of knowledge of the laparoscopic anatomy of the gallbladder pedicle.The arterial system of human body is often subjected to a good number of variations. Therefore, trying to find out variations in origin of right and left hepatic arteries and also cystic artery will surely be a useful endeavor for an Anatomist and Autopsy Surgeon, moreover such an effort will help the surgeons in planning and operating upon the hepatobiliary system. **Method:**The present work was carried out in the Department of FMT, NRSMCH, Kolkata in collaboration with the Department of Anatomy, Medical College, Kolkata over a period of one year to find out variations ion origin of right and left hepatic arteries and cystic artery. Fifty cadavers of both sexes were subjected to detail dissection method based on inclusion and exclusion criteria. The study was prospective, cross sectional, observational, autopsy based study.

Conclusion: In 92% cases total number of branches from the HAP were three, four branches were arising from it in 6% cases, whereas >four branches from the HAP in remaining 2% cases.The branching pattern of the HAP at the porta hepatis showed bifurcation in 96 % cases, whereas HAP showed trifurcation pattern at porta hepatis in 4% cases.Any source of origin of the RHA and LHA other than the HAP was recorded as 0%. The percentage of occurrence of accessory or replaced RHA was 0%.This was also the case with LHA. The present study revealed the RHA (92%) being the commonest source of origin of cystic artery. In 8% cases cystic artery represented variant origin. Variant origins of CA were represented by the HAP (6%) and GDA (2%).In 96% of cases, the cystic artery was single. Remaining 4% of cadavers showed presence of more than one cystic artery, the number being two.Most significant finding in this present study according to the researcher is the presence of double cystic arteries.

Key Words: *laparoscopy,Cholecystectomy, cystic artery, hepatic artery proper, porta hepatis, right hepatic artery, left hepatic artery*

Introduction

Laparoscopic Cholecystectomy is widely accepted as the gold standard in the treatment of cholelithiasis.[1]

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This new technique was initially associated with a significant increase in morbidity, and in particular, in iatrogenic biliary injury and arterial haemorrhage[2-4] perhaps due to a lack of knowledge of the laparoscopic anatomy of the gallbladder pedicle. Therefore, the laparoscopic surgeon has to deal with the new anatomical views and must be aware of the possible arterial and biliary variants.The anatomical knowledge of different variations of hepatic and cystic arteries is required

to reduce the number of iatrogenic complications in traditional and laparoscopic hepatobiliopancreatic surgery. Likewise, the surgeon applies this knowledge in the surgical management of liver trauma in the region, aneurysm of the hepatic artery, liver transplant surgery, pancreaticoduodenectomy, radical gastrectomy and countless surgeries themselves of this complex anatomical region.

The arterial system of human body is often subjected to a good number of variations. Therefore, trying to find out variations in origin of right and left hepatic arteries and also cystic artery will surely be a useful endeavor for an Anatomist and Autopsy Surgeon, moreover such an effort will help the surgeons in planning and operating upon the hepatobiliary system.

The liver and the gallbladder constitute the main parts of the hepatobiliary system. They are supplied by the branches of the coeliac trunk, one of the ventral branches of the abdominal aorta. Actually these hepatobiliary structures are supplied by the branches of the hepatic artery proper, one of the terminal branch of the common hepatic artery which via its gastro duodenal branch supplies parts of stomach, duodenum and lower part of the common bile duct, while the proper hepatic artery provides the right gastric artery and then divides into the right and left branches, which supply the right and left liver lobes. The right hepatic artery provides a cystic branch, which passes through Calot's triangle and supplies the gallbladder.

In addition to the variability in origin of the cystic artery, its course can also follow diverse paths, often in close proximity to the common bile duct. A bend in the course of the right hepatic artery, throwing it into the configuration of a caterpillar hump or Moynihans Hump invites injury unless it is carefully dissected free. A very short cystic artery also puts the hepatic artery at risk. Occasionally, the right hepatic artery courses anterior to the common bile duct.

In spite of considerable surgical importance, there are not many studies on variations in origin of right and left hepatic arteries and cystic artery particularly from this part of India which drives the present researcher to pursue this dissection oriented study on hepatic and cystic arteries in human cadavers with particular inclusion and exclusion criteria.

Introductory remarks about the hepatic arteries

The coeliac trunk terminates by dividing into the left gastric, splenic, and common hepatic arteries. The common hepatic artery normally terminates by dividing into the gastroduodenal and proper hepatic arteries. The gastroduodenal artery divides into the superior pancreaticoduodenal and right gastroepiploic arteries, the proper hepatic artery ascends in the right free border of the lesser omentum up to porta hepatis. At the porta hepatis the proper hepatic artery divides into right and left branches. It provides theright gastric artery and then divides into the right and left hepatic branches, which supply the right and left liver lobes. The right hepatic artery provides a cystic branch, which passes through Calot's triangle and supplies the gallbladder.

Brief Anatomy of RHA, LHA, Cystic Artery

After its origin RHA crosses anterior to the portal vein from left to right and passes behind the common hepatic duct to enter the Calot's triangle where it lies to the left of the cystic duct. As it approaches the cystic duct, it gives off the cystic artery and then turns upwards behind the right hepatic duct to enter the right lobe of liver. The LHA takes origin from the proper hepatic artery. It passes anterior and to the left of the portal vein. Then it ascends upwards to reach the left lobe of the liver. *A vessel which supplies a liver lobe in addition to its usual vessel is defined as an accessory hepatic artery. A replaced hepatic artery is a vessel that does not take origin from an orthodox position and is the sole supply to that lobe. Thus the aberrant arteries may be either replaced or accessory*. The common variations include replaced right hepatic artery taking origin from superior mesenteric artery and replaced or accessory left hepatic artery arising from the left gastric artery. Rarely accessory right and/or left hepatic artery may arise from gastroduodenal artery or aorta.The replaced right hepatic artery arising from superior mesenteric artery, runs behind portal vein and bile duct in the lesser omentum can be injured during surgical resection of pancreatic head. The replaced left hepatic artery can be injured during mobilization of stomach.The cystic

artery commonly arises from RHA and is given of in calot`s triangle. The course and length of cystic artery is variable in calot`s triangle. Although the artery classically traverses the triangle almost at the centre, but it can be very close or lower than the cystic duct.

Aims & Objectives

The aim of this dissection oriented study was to find out the variations regarding originof the extrahepatic part of hepatobiliary arterial system involving the common hepatic artery, hepatic artery proper, the RHA and the LHA (UP TO PORTA HEPATIS) and the cystic artery. The data will help the surgeons and the interventional radiologist to decrease the complications during and after the procedure so that patient can lead a quality life.

Objectives:-

1. To study the variations in origin of RHA and LHA and particularly the presence of accessory or replaced RHA and LHA.

2. To study the variation of origin of cystic artery.

Materials & Methods

Study Design: Cross-sectional observational prospective study

Study Tools:

1. Dissection Instruments

2. Digital Camera

3. Computer for data analysis

Study Technique: A group of 50 dead bodies including well embalmed and preserved (both male and female) and also dead bodies came for Autopsy examination above 18 years of age were selected. Anterior abdominal wall with parietal peritoneum was reflected as described in the *Cunningham's Manual of Practical Anatomy*[5].

The greater part of right hypochondrium was occupied by liver. Inferior margin of liver was lifted up and lesser curvature of stomach traced from the entry of abdominal part of esophagus up to the thickened pyloric sphincter. The lesser omentum with its right free margin was identified between the lesser curvature of stomach with the ascending part of duodenum and the liver. The epiploic foramen was identified. At its left boundary the free margin of lesser omentum was felt thickened by palpation. The superficial layer of lesser omentum was stripped off and 3 underlying structures were identified. The hepatic artery proper (HAP) the common bile duct and the portal vein whether or not maintaining their usual position and mutual relationship were sought after in the right free margin of the lesser omentum.

Afterwards the HAP was traced downwards up to the origin of gastroduodenal artery (GDA) which was coursing behind the 1st part of duodenum. The GDA was then examined for any branch to GB from it. From the point of its division into terminal branches the HAP and the GDA the common hepatic artery (CHA) was traced towards the left up to its origin, the coeliac trunk. From the celiac trunk the left gastric artery was traced towards the esophageal end of stomach and it was examined for the presence of any accessory or replaced LHA. Similarly the presence of accessory or replaced RHA was also searched. Any variation regarding source of originof cystic artery were carefully examined. The observations were both recorded on paper and photographed.

Inclusion Criteria: Adult human cadavers above 18 yrs of age.

Exclusion Criteria:

1. Paediatric cadavers below 18 yrs of age

2. Cadavers above 18 years where dissection cannot be done because of pathology in and around porta hepatis.

3. Decomposed dead bodies

4. Dead bodies came for autopsy with gross abdominal injury involving hepato-billiary system.

Study Period: One Year

Study Duration: 1st September 2015 to 31st August 2016.

Study Area: The present study was conducted in the Department of Anatomy, Medical College and Hospital, Kolkata in collaboration with Dept of Forensic

Medicine, NRS Medical College, Kolkata.

Study Population: A group of 50 cadavers

Statistical Analysis: Collected data were analyzed and statistical test were done with the help of appropriate statistical tools.

Results and Analysis

The study on Extrahepatic part of hepatobiliary vasculature was conducted on 50 cadavers, out of which 40 were male and 10 were female. The study included the Hepatic Artery Proper, the portion of Right and the Left Hepatic Arteries outside the porta hepatis along with the cystic artery.The source of origin of HAP was noted .The branching pattern along with total number of branches taking origin from it, the emerging order of different branches including the presence of any unusual branch was also studied. The RHA and LHA (particularly the part of RHA and LHA outside the porta hepatis) were studied regarding their source of origininclude the presence of accessory or replaced RHA and LHA, if any. The cystic artery was studied with regard to its source of origin. In 92% cases total number of branches from the HAP were three, four branches were arising from it in 6% cases, whereas >four branches were originating from the HAP in remaining 2% cases.

The branching pattern of the HAP at the porta hepatis showed bifurcation (where the HAP divided in to the RHA and LHA and CA was taking origin from the RHA.) in 96 % cases, whereas trifurcation (the HAP divided into RHA,LHA and CA) was seen in 4% 0f specimens.

No variation regarding source of origin other than the HAP was recorded. The percentage of occurrence of accessory or replaced RHA was 0%. This was also similar in case of LHA.

The cystic artery was seen to take its origin from the RHA in 92% cases, from the HAP in 6% of cases and from the GDA in remaining 2%.

On the basis of these observations statistical analysis of the obtained data was done.

Table 1: Number of branches from Hepatic Artery Proper

Total No Of Branches From HAP	Total No Of Case (n=50)
Three (RHA,LHA,RGA)	46
Four(RHA,LHA,RGA &CA)	3
Greater than Four	1

Table 2: The Branching Pattern of Hepatic Artery Proper at Porta Hepatis

Branching Pattern	Total no of case(n=50)
Bifurcation	48(96%)
Trifurcation	2(4%)

Table 3: Source of origin of cystic artery

Source of origin	Total no of case (n=50)
RHA	46(92%)
HAP	3(6%)
GDA	1(2%)
LHA	0 (0%)
CHA	0 (0%)
CT	0 (0%)
SMA	0 (0%)
Others	0 (0%)

Table 4: Total number of Cystic Arteries present

Number of CA	Total no of case (n=50)
SINGLE	48 (96%)
MULTIPLE(2 in number)	2 (4%)

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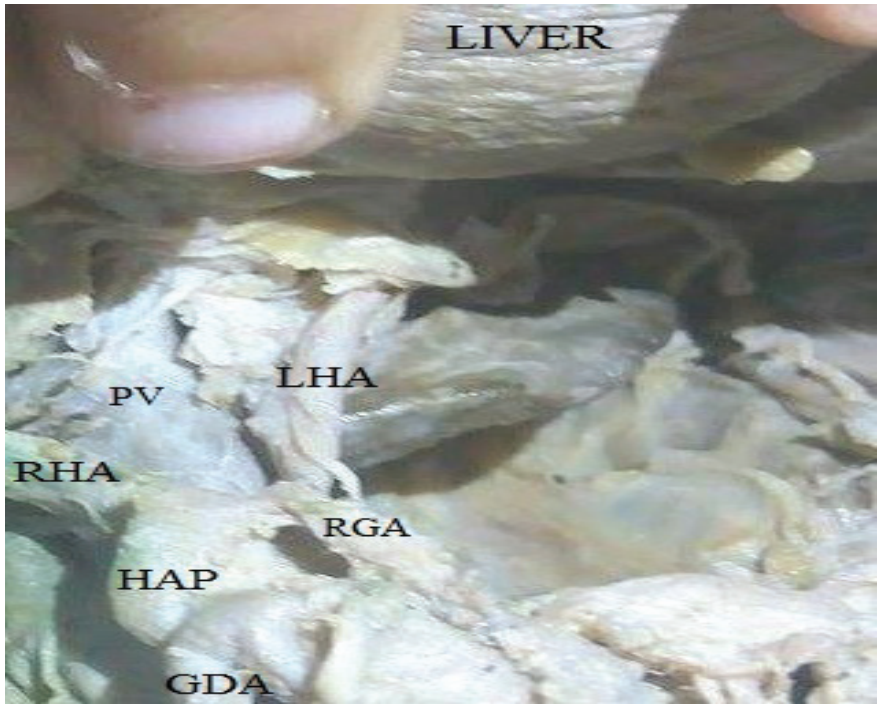

Fig.1: HAP divided into RHA and LHA. LHA providing origin to RGA

RHA- Right Hepatic Artery; LHA- Left Hepatic Artery; PHA- Proper Hepatic Artery [also known as Hepatic Artery Proper (HAP- Hepatic Artery Proper, GDA- Gastroduodenal Artery, RGA- Right Gastric Artery. PV – Portal Vein).

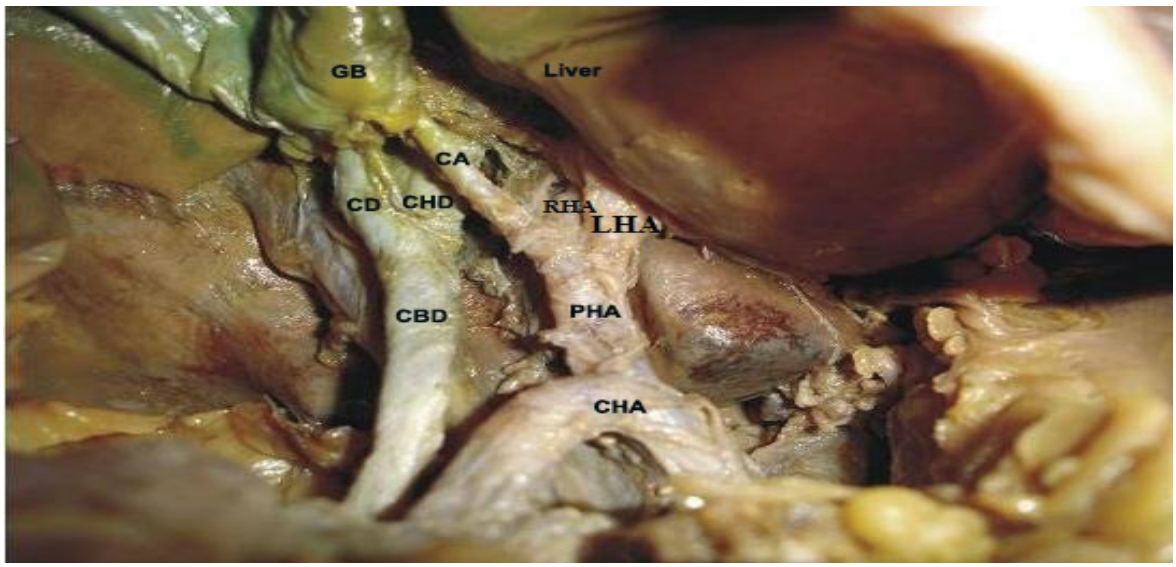

Fig.2: Showing Cystic Artery arising from PHA passing anterior to CHD.

RHA- Right Hepatic Artery; LHA- Left Hepatic Artery; PHA- Proper Hepatic Artery [also known as Hepatic Artery Proper (HAP)]; CA- Cystic Artery; CHA- Common Hepatic Artery; GB- Gall Bladder; CD- Cystic Duct; CHD- Common Hepatic Duct; CBD- Common Bile Duct

Discussion

The present study was done in 50 cadavers by gross dissection to observe the source of origin, branching pattern including emergence of any unusual branch of Hepatic Artery Proper, the extra-hepatic portions of RHA and LHA and most importantly the cystic artery. No variation was seen in source of origin of hepatic artery proper, i.e. it was taking origin from the common hepatic artery in all the cases. In 92% cases the HAP was having three usual branches, the RHA, LHA & the RGA. In 6% cases the HAP had cystic artery taking origin from it. In these cases the total numbers of branches from HAP were four. In one out of fifty cases HAP had greater than four branches. One branch was seen to supply the cystic duct in this particular case.

The branching pattern of HAP at porta hepartis:

The comparison of previous study with the present study:

Kalyankar[6] et al. found PATTERN A in 86% cases, PATTERN B in 9% cases and PATTERN C & D in 4% and 1% cases respectively. Thompson & Browne (1940) also noted PATTERN C & D in less than 2% cases. The finding of PATTERN A of present study is slightly higher than the finding of Kalyankar [6] et al. whereas the percentage of PATTERN C is similar with the percentage given by Kalyankar al.

No variations were seen regarding the source of origin of both RHA and LHA. In one of the fifty cases the RHA gave origin to two cystic arteries. Both of them were traversing through the calot's triangle to supply the GB. Also in one of the cases LHA provided a branch outside the porta hepatis which was going towards the segment IV of liver.

In another case the LHA gave origin to the RGA which was also not an usual branch from the LHA.

The Cystic Artery

In the present study most common origin of cystic artery was RHA (92%). This observation is close to the findings of some other studies done by Flint [7] et al. (98%), De Silva [8] et al. (96%), Khalil M [9] (90%), R Gawali[10] (97%) and Tejaswi HL[11] et al. (92%). The findings of this present study are much higher than observations from Michels NA [12] (77%)

The Number of Cystic Artery

In this study, cystic artery was present as a single vessel in 96% cases whereas in 4% cases GB had more than one cystic arteries. This finding of double cystic arteries in the present study conforms with findings of Patil S [14] et al (6.6%) and Flisinski [15] et al (2.94%).

The percentage of double cystic artery is lower than studies done by Flint [7] et al (15.5%) and Balija [16] et al (21.1%). Balija et al found triple cystic artery in 0.1% cases.

In the present study, one out of fifty cases represented double cystic artery where both the cystic arteries were taking origin from the RHA. After taking origin from RHA, they passed anteriorly & posteriorly with respect to CHD encircling the CHD. In this case, bile flow could be obstructed because of compression of CHD.

In this study cystic artery represented its commonest origin in 92% cases and variant origin in 8% cases. Study by Saidi [17], Karanja and Ogengo suggest a relatively more constant anatomy in their cohort studies than those in an American series where aberrant cystic arteries (origin other than right hepatic artery) occurred in 21% of cases and that for Ethiopians with a 24.5% prevalence of aberrant cystic arteries. These wide variations are due to methodological differences but possibly also to actual population differences.

Summary and Conclusion

A study of extrahepatic part of hepatobiliary vasculature was carried out in the Department of Anatomy, Medical College, Kolkata in collaboration with Dept of Forensic Medicine, NRS Medical College, kolkata. Fifty cadavers of both sexes (observing proper inclusion & exclusion criteria) were subjected to detail

dissection method and variations in origin and branches of right and left hepatic arteries and cystic arteries are examined. The findings so obtained were compared to similar such studies done in the past.

Origin of HAP showed no variation.

In 92% cases total number of branches from the HAP were three, four branches were arising from it in 6% cases, whereas >four branches from the HAP in remaining 2% cases.

The branching pattern of the HAP at the porta hepatis showed bifurcation (where the HAP was divided in to the RHA and LHA and CA was taking origin from the RHA.) in 96 % cases, whereas HAP showed trifurcation pattern at porta hepatis in 4% cases (where HAP divided in to RHA ,LHA and CA).

Any source of origin of the RHA and LHA other than the HAP was recorded as 0%. The percentage of occurrence of accessory or replaced RHA was 0%.This was also the case with LHA.

The present study revealed the RHA (92%) being the commonest source of origin of cystic artery. In 8% cases cystic artery represented variant origin. Variant origins of CA were represented by the HAP (6%) and GDA (2%).

In 96% of cases, the cystic artery was single. Remaining 4% of cadavers showed presence of more than one cystic artery, the number being two.

Most significant finding in this present study according to the researcher is the presence of double cystic arteries. In the present study, one out of fifty cases represented double cystic artery where both the cystic arteries were taking origin from the RHA .After taking origin from RHA ,they passed anteriorly & posteriorly with respect to CHD encircling the CHD .In this case, bile flow could be obstructed because of compression of CHD. During dissection of calot's triangle, the postetriorly lying cystic artery should be taken care of to prevent haemorrhage. Another case with double cystic artery represented the compound cystic artery variety of Ding et al. In this case one artery was arising from the RHA and traversing the calot's triangle and another cystic artery was originating from the HAP and it was lying outside the calot's triangle.

To facilitate the safe operative procedures on the liver and gall bladder, there is a need of exact and comprehensive knowledge of the varied patterns of hepatic and cystic arteries. Because variations are very common in hepatic and Cystic arteries. Sound knowledge will allow the surgeons to practice safe laparoscopic or open Cholecystectomy, liver resections and vascular recombination in transplantation and there by avoid errors and patient morbidity.

Abbreviations:

HAP- Hepatic Artery Proper (also referred as PHA)

LC- Laparoscopic Cholecystectomy

LDLT- Living Doner Liver Transplantation

LHA- Left Hepatic Artery

MHA- Middle Hepatic Artery

PHA- Proper Hepatic Artery

RHA- Right Hepatic Artery

SMA- Superior Mesenteric Artery

AB RHA- Aberrant Right Hepatic Artery

AB LHA- Aberrant Left Hepatic Artery

CA-Cystic Artery

CHA- Common Hepatic Artery

CHD- Common Hepatic Duct

CBD- Common Bile Duct

CT- Coeliac Trunk

GB- Gall Bladder

GDA- Gastro Duodenal Artery

TAE- Trans Arterial Embolization

TACE- Trans Arterial Chemo Embolization

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Ø **Conflict of Interest:** nil

Ø **Ethical Clearance:** taken from Institutional Ethics Committee of Medical College, Kolkata & NRS MCH

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