STUDY OF VARIATIONS OF EXTRA HEPATIC BILIARY APPARATUS IN CADAVERS

By

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In partial fulfillment of the requirements for the degree of

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Under the guidance of

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LIST OF ABBREVIATIONS USED

1. GB- Gallbladder
2. CD- Cystic duct
3. CHD- Common hepatic duct
4. CBD- Common bile duct
5. CA- Cystic artery
6. RHA- Right hepatic artery
7. CHA- Common hepatic artery
8. HAP- Hepatic artery proper
9. GDA- Gastroduodenal artery
10. Acc. RHA- Accessory right hepatic artery
11. Acc. CA- Accessory cystic artery
12. Acc. CD- Accessory cystic duct
13. ERCP- Endoscopic retrograde cholangiopancreatography
14. MRCP- Magnetic resonance cholangiopancreatography
15. No. - Number

ABSTRACT

Background and objectives:

A precise knowledge of anatomy of extrahepatic biliary apparatus is a must while doing surgical procedures like laparoscopic and open cholecystectomies, liver transplantation, imaging techniques such as ERCP and MRCP. The aim is to study the normal anatomy and variations of the extrahepatic biliary apparatus.

Materials and Methods:

20 specimens of extrahepatic biliary apparatus and arteries related to it were dissected, painted with green and red acrylic paint and observations recorded. Then specimens were removed from cadavers and preserved.

Results:

The gall bladder was single in all the specimens. It was present in the fossa for gall bladder over the inferior surface of right lobe of liver. The gall bladder was normal in shape in 95% specimens and Hartman's pouch was seen in 5% specimens only.

Most common type of termination of cystic duct was angular type. Normal level of union of cystic duct with common hepatic duct was most commonly observed.

RHA was arising from hepatic artery proper in 70% specimens (most common) and least commonly from superior mesenteric artery in 10% specimens.

Cystic artery had origin from right hepatic artery in 85% specimens (most common) and least commonly from aberrant right hepatic artery in 15% specimens.

Accessory right hepatic artery was observed in 15% specimens. Accessory cystic artery was observed in 20% specimens. Accessory cystic ducts were found in 10% of specimens.

Interpretation and conclusion:

From this study it can be concluded that the arterial variations are more common as compared to ductal variations in extrahepatic biliary apparatus. The knowledge of variations in the extrahepatic biliary ductal system and Calot's triangle is important for surgical gastroenterologists, radiologists and general surgeons.

Keywords: Extrahepatic biliary apparatus, gallbladder, cystic duct, common hepatic duct, common bile duct, right hepatic artery, cystic artery.

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INTRODUCTION

Variation is the law of nature. Every human is unique anatomically to such an extent that even identical twins are not exactly alike. The variations in the morphological characteristics of the extrahepatic biliary system are numerous. It has been stated that the extrahepatic biliary system has more anomalies in one cubic centimetre of the space around the region of the cystic duct than any other part of the body. Anomalies of the extrahepatic biliary system can arise from the gallbladder, cystic duct, hepatic ducts or the common bile duct as a result of aberrations of normal embryological development. The incidence of congenital anomalies of the extrahepatic biliary system varies between 0.58% and 47.2%. It has been observed that, vascular anomalies are more frequent than those of the ductal system. These anomalies add to operative difficulties during cholecystectomy.[1]

The gall bladder plays an important role in the metabolisms of bile salts and subsequently that of fat. The gall bladder in addition to congenital anomalies has various metabolic, endocrine, obstructive, inflammatory and malignant diseases. The gallstone obstructing the passage leads to about 80% of operations done upon gall bladder and bile ducts.

"Technically Gall bladder surgery is much the most difficult of the any abdominal surgery and inadequate appreciation of the abnormalities of this region doesn't lessen the risk"

- Flint ER [2] –

Cholelithiasis is common worldwide. Laparoscopic and open cholecystectomies are the two methods to treat symptomatic gall stones. Surgical treatment mandates careful exploration of Calot`s triangle and proper identification of extrahepatic biliary and vascular channels. Various studies have shown that a typical

text book anatomy arrangement of these structures is present in only 50% patients, the remaining shows some variation in anatomy, leading to increased risk of injury during surgical procedures.[3] Failure to identify these variations may lead to injury, division or ligation of major bile ducts or arteries with grave consequences. Abnormalities of the major ducts and accessory hepatic duct during cholecystectomy are the most frequent cause for postoperative complications such as leakage of bile, fistula, necrosis of liver and hepatic failure. Biliary peritonitis leads to more serious trouble, if unrecognized during surgery.

Anatomic variations in and around Calot's triangle are frequent which can affect biliary tree and cystic artery. A good knowledge of Calot's triangle is important for conventional and laparoscopic cholecystectomy. Calot's triangle is an important imaginary referent area for biliary surgery.[4]

Cystic artery bleeding is a troublesome complication during laparoscopic cholecystectomy. This may lead to injuries to duct, as during the process of clamping the vessels, ducts can also be included in ligature along with artery. If surgery is performed incorrectly, injury to the extrahepatic bile duct or intraabdominal organs is inevitable. The reported incidence of conversion to open surgery because of blood vessel injuries is approximately 0% - 1.9% during laparoscopic cholecystectomy and its mortality is about 0.02%. Safe laparoscopic cholecystectomy demands a good knowledge of the anatomy of the cystic artery and its variations.[4]

The extrahepatic biliary tree can be visualized preoperatively using imaging techniques such as ERCP and MRCP, however these are expensive and time consuming and hence not advisable in all cases. Instead a sound knowledge of the normal anatomy of extrahepatic biliary tree and the accompanying vessels and its variation has been recommended to decrease the risk of complications.[3]

In an era of ever-increasing laparoscopic, endoscopic and percutaneous surgical/ interventional procedures of the hepatobiliary system, it is extremely important to have adequate knowledge of such variations before the actual procedure is performed. It could prevent many potential surgical complications due to unrecognized anatomical variations of the biliary tree.[5]

The importance of variations in the extrahepatic biliary ductal system and calot's triangle has been much observed by the surgical gastroenterologists, radiologists and general surgeons.

Such an extensive clinically oriented topic created much interest in me which in turn provoked me to dissect and analyse the variations in extrahepatic biliary apparatus.

OBJECTIVES OF STUDY

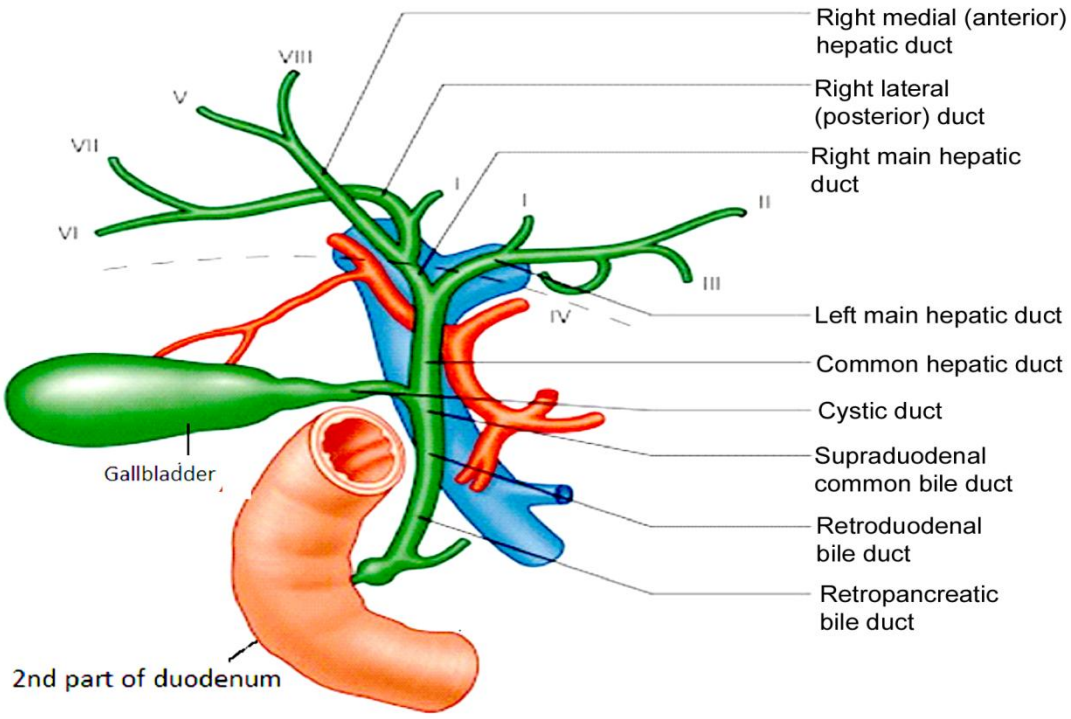
1. This work has been done to study the normal anatomy and variations of extrahepatic biliary apparatus.

REVIEW OF LITERATURE

Gross anatomy of extrahepatic biliary apparatus

The extrahepatic biliary apparatus consists of the right and left hepatic ducts, the common hepatic duct, the cystic duct, the gallbladder and the common bile duct.[6]

Photograph no.1-Normal anatomy of extra hepatic biliary apparatus



Hepatic bile ducts

The main right and left hepatic ducts emerge from the liver and unite near the right end of the porta hepatis as the common hepatic duct. The extrahepatic right duct is short and nearly vertical while the left is more horizontal and lies along the base of segment IV. The common hepatic duct descends approximately 3 cm before being joined on its right at an acute angle by the cystic duct to form the common bile duct.

The common hepatic duct lies to the right of the hepatic artery and anterior to the portal vein in the free edge of the lesser omentum.[6]

Cystic duct

The cystic duct drains the gallbladder into the common bile duct. It is between 3 and 4 cm long, passes posteriorly to the left from the neck of the gallbladder, and joins the common hepatic duct to form the common bile duct. The junction usually occurs near the porta hepatis.[6]

The gall-bladder

The gall-bladder is pear shaped, attached to the common bile duct through cystic duct. In the adult it is 7 to 10 cm long with a capacity of 50 ml. It usually lies in a shallow fossa on the under surface of the right lobe of the liver.[6]

The gallbladder has three parts-

Fundus: the wide blunt end that usually projects from the inferior border of the liver at the tip of the right 9^{th} costal cartilage in the midclavicular line.

Body: main portion that contacts the liver, transverse colon and superior part of the duodenum.

Neck: narrow tapering end opposite the fundus and directed towards porta hepatis, it typically makes an S-shaped bend and joins the cystic duct.[7]

Common bile duct

The common bile duct is formed near the porta hepatis, by the junction of the cystic and common hepatic ducts and is usually between 6 and 8 cm long. Its diameter tends to increase somewhat with age but is usually around 6 mm in adults. It descends posteriorly and slightly to the left, anterior to the epiploic foramen, in the right border of the lesser omentum, where it lies anterior and to the right of the portal vein and to

the right of the hepatic artery. It passes behind the first part of the duodenum with the gastroduodenal artery on its left, and then runs in a groove on the superolateral part of the posterior surface of the head of the pancreas. The duct lies anterior to the inferior vena cava.[6]

Hepatopancreatic ampulla (of vater)

The union of the common bile duct and the pancreatic duct forms the ampulla of Vater.[8]

Calot's triangle

It is a triangular space formed between the cystic duct, the common hepatic duct and the inferior surface of segment V of the liver. This space usually contains the cystic artery as it approaches the gallbladder, the RHA, the cystic lymph node and lymphatics from the gallbladder, one or two small cystic veins, the autonomic nerves running to the gallbladder, and some loose adipose tissue.[6, 9]

Blood supply of extrahepatic biliary apparatus

The extrahepatic biliary tract receives branches from the cystic artery, right hepatic artery and posterior branch of the superior pancreaticoduodenal artery. Small veins from the biliary tract drain to the portal vein or enter the liver.[8]

Right hepatic artery

The hepatic artery proper at the porta hepatis divides into right and left hepatic arteries. The right hepatic artery crosses posterior to the common hepatic duct and divides into anterior branch which supply segment V and VIII, and a posterior branch which supply segment VI and VII.[6]

Cystic artery

The cystic artery usually arises from the right hepatic artery. It usually passes posterior to the common hepatic duct and anterior to the cystic duct to reach the superior aspect of the neck of the gallbladder and divides into superficial and deep branches. The superficial branch ramifies on the inferior aspect of the body of the gallbladder, the deep branch on the superior aspect. These arteries anastomoses over the surface of the body and fundus.[6]

Innervation

The gallbladder and the extrahepatic biliary tree are innervated by branches from the hepatic plexus. The retroduodenal part of the common bile duct and the smooth muscle of the hepatopancreatic ampulla are also innervated by the twigs from the pyloric branches of the Vagi.[6]

Embryology

The hepatic rudiment first appears on the 18th day in the 7th somite embryo. In the 19th somite embryo, it can be recognised in transverse section as a 'T' shaped diverticulum of the endoderm from the convexity of the future duodenal loop.

The diverticulum projects ventrally and cranially into the surrounding mesoderm of the septum transversum. The hepatic diverticulum will eventually give rise to the endodermal portion (future parenchyma) of the liver and the epithelium of the biliary apparatus.

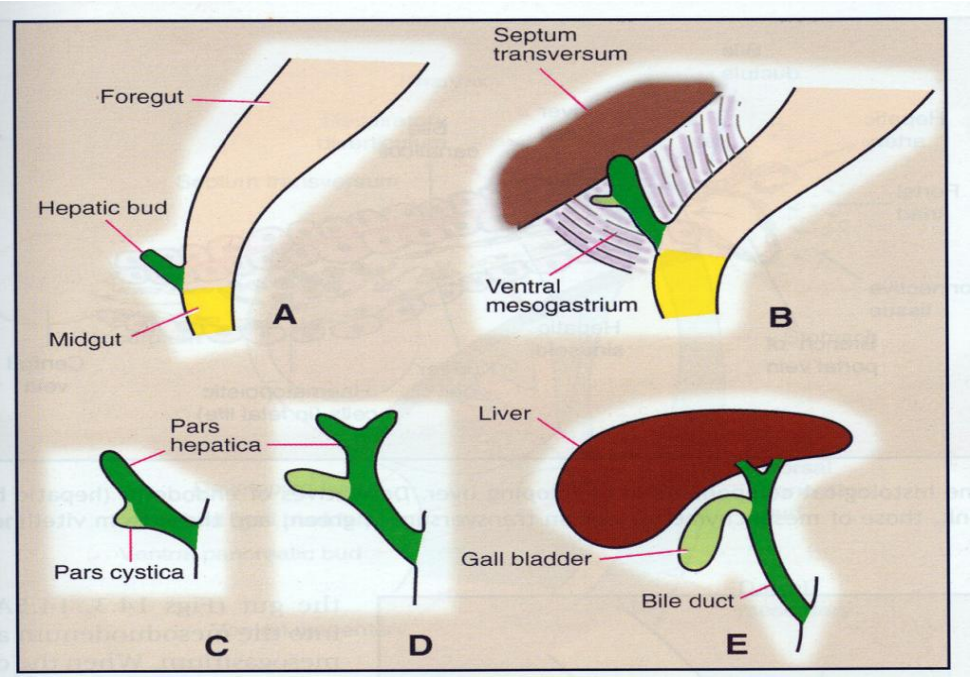
By the 23rd - 25th somite stage, the hepatic diverticulum enlarges and a localized proliferation of endodermal cells which appears as a bulge on its ventrocaudal surface results in the division of the diverticulum into a large cranial portion 'pars hepatica' and a small caudal portion 'pars cystica'. The pars cystica gives rise to gall bladder and cystic duct. The pars hepatica grows cranially away from the pars cystica and gives rise to the parenchymal elements of the liver, the intrahepatic ducts and the right and left hepatic ducts. That part of the original pars hepatica adjacent to the pars cystica becomes the common hepatic duct.

The thick walled pars hepatica sends out proliferations of endodermal cells in the form of solid hepatic cords into the adjacent mesenchyme of the septum transversum. These cords anastomose around and isolate either small clusters of the mesenchymal cells of the septum transversum or small preformed vesicles in this mesenchyme.

As the hepatic cord continue to grow and anastomose, the isolated vesicles containing blood cells becomes confluent to form continuous channels which become small blood vessels.

With the increased proliferation of the hepatic parenchyma, there is increase in the size and length of the gall bladder, cystic duct and common bile duct.

Photograph no. 2 -- showing development of extra hepatic biliary apparatus



At about the 46th day, the mesoderm around the extrahepatic ducts begins to migrate into the liver along the major branches of the portal vein. As this mesoderm accumulates round the portal vessels, the adjacent parenchymal cells develop into duct epithelium. The migration of the mesoderm and the transformation of adjacent parenchymal cells of the tubules into typical epithelial duct cells progress from the hilum of liver peripherally to the terminal branches of the portal vein. Peripherally, where there is little or no developing connective tissue, there is an abrupt change between the duct cells and the parenchymal cells although the two cell types are continuous. This abrupt transition is found in adult, between the bile canaliculi and intrahepatic ducts.[10]

Review of previous work

The extrahepatic biliary apparatus consist of the right and left hepatic ducts, the common hepatic duct, the cystic duct, the gallbladder and the common bile duct.

The importance of variations in the extrahepatic biliary apparatus and calot's triangle has been much observed by the surgical gastroenterologists, radiologists and general surgeons. Various studies done on extra hepatic biliary apparatus are reported below.

Aristotle[11] (384-322 B.C.) reported absence of gallbladder in animals.

Galen[11] (A.D. 130-200) stated that humans have a single bile duct or perhaps paired bile ducts.

Rhazes[12] (A.D. 850- 923) of Persia and Abicenna (A.D. 980- 1037) appreciated the gallbladder but lacked knowledge of the common bile duct.

Berengario da Carpi[11] (1522) wrote that "sometimes a man lacks a gallbladder, he is then of infirm health and a shorter life."

Glisson[12] (1654) in his book Anatomia Hepatis described biliary anatomy on the basis of cast and injection studies. He was first to mention a sphincteric mechanism around the orifice of the common bile duct.

Bergman[11] (1701) reported first definite case of absence of human gallbladder.

Morgagni[11] (1769) reported deformations of the gallbladder, he was first to see torsion of the gallbladder.

Bobbs[11] (1867) described hydrops of gallbladder and performed first successful removal of gallstones.

Von Wyss[11] (1870) studied variations of the common bile duct.

Calot[11] (1891) gave original description of triangle of Calot.

Deve[11] (1903) was the first to describe intrahepatic gallbladder (gallbladder completely submerged in the liver substance).

Eisendrath[13] (1918), in his study on 100 specimens, showed the types of union of cystic duct with CHD. In that, angular type of union was observed in 75% cases, parallel type of union in 17% cases, and spiral type in 8% cases. He also described that extrahepatic union of right and left hepatic ducts was seen in 100%, intrahepatic union was not seen and the frequency of occurrence of accessory ducts was 0% in his study. Regarding the relationship of CA with common hepatic duct, in 27 cases the CA crossed ventral to common hepatic duct, and in 73 cases the CA crossed dorsal to common hepatic duct.

Flint ER[2] (1922-23) studied 200 subjects and found that right hepatic artery was originating from hepatic artery proper in 79% cases and from superior mesenteric artery in 21% cases. He found that right hepatic artery was crossing the common hepatic duct from behind in 68% cases, and from front in 12.5% cases.

He found CA originating from the right hepatic artery in 98% cases, the LHA in 1.5% cases and the GDA in 0.5% case. CA passed in front of the common hepatic duct in 16% cases and passed behind it in 84% cases.

He noted the accessory cystic artery in 31 cases, out of which it arose from right hepatic artery in 16 cases, from left hepatic artery in 3 cases, from gastroduodenal artery in 11 cases and from superior pancreaticoduodenal artery in 1 case.

Beaver[14] in 1929 dissected extra hepatic biliary tracts of the 57 subjects and concluded that angular mode of union between the cystic and hepatic ducts constituted 58 % of all the dissections. 26.3% of the ducts were of the short parallel type (the cystic ducts which follow the hepatic bile duct as far as the upper border of

the duodenum) and 7% were of the long parallel type (the ducts which extend farther, to within 1 cm. of the ampulla of Vater). 7% of the cases were of anterior spiral variation and 5.3% were of the posterior spiral type.

Thompson[15] dissected 50 specimens during 1933**,** and stated that extrahepatic union of right and left hepatic ducts occur in 90% cases and intrahepatic union of right and left hepatic ducts occur in 10% cases. The union of cystic with common hepatic duct was angular in 45 cases, parallel in 3 cases and spiral in 2 cases.

Lurje[16] (1937) studied elaborately the extrahepatic biliary passage by dissecting 194 cadavers. His observations were-

Relations of the fundus of gallbladder to the liver edge-

In 33% cadavers the fundus was 1 to 2 cm. above and behind the anterior margin of the liver. In 13.9% cadavers, the fundus extended down to the anterior margin of the liver. In 53.1% cadavers it protruded 0.5 to 4 cm. below the margin.

Relations of cystic and hepatic duct-

Cystic duct joined hepatic duct at acute angle in 46.9% of cases. Cystic duct followed the right border of the hepatic duct for some distance before entering it in 30.9% of cases.

Cystic duct made a spiral course behind the hepatic duct and entered it on its left anterolateral surface in 6.7% of cases. Cystic duct made a spiral course and followed the posterior surface of hepatic duct for some distance and entered it posteriorly in 15.5% of cases.

Supernumerary bile ducts- the supernumerary bile ducts were noted in 11.3% cases.

In 10.8% cadavers when the right hepatic artery arose from the superior mesenteric, the common duct was located in front of the right hepatic artery.

Michels NA[17] (1951), statistically estimated the origins of cystic artery from 200 bodies. Cystic artery was single in 75% of cases. Out of which 70% were arising from right hepatic artery. In 5% it arose from left hepatic, hepatic artery proper, retroduodenal or gastroduodenal arteries. Site of origin of the single cystic artery occurred in the cystic triangle in 57% of the 200 cases. He found double cystic artery in 25% cases, the superficial and deep branches arose separately from the same artery or from different sources.

He observed the aberrant right hepatic artery in 26% cases. Of which 18% were replaced right hepatic and 8% were accessory right hepatic. The most common site of origin of an aberrant right hepatic artery was superior mesenteric artery.

When the cystic artery arose from right hepatic artery it passed posterior to common hepatic duct. When it arose from other sources it crossed anterior to common hepatic duct. In 88% of cases right hepatic artery crossed posterior to common hepatic duct and in 12% of cases it crossed anterior to common hepatic duct.

Toufeeq AK[18] (1953) studied fifty cases of cholecystectomy. The anatomical variations of cystic duct found in his study were:

1. 70% cases had normal anatomy.
2. In 12% cases the cystic duct joined the common hepatic duct on its left.
3. In 12% cases no cystic duct was present.

In his study the normal arrangement of right hepatic and cystic arteries was noted in 78% of the cases. He described the following variations of right hepatic and cystic arteries-

A. The RHA was passing in front of common hepatic duct in16% cases.
B. In 2% of cases cystic artery originated from the right hepatic as it was given off from common hepatic artery and crossed in front of common hepatic duct.

C. The cystic artery originated from common hepatic artery and crossed in front of common hepatic duct in 2% of the cases.

William et al.[19] in 1955, reported following abnormalities of the bile ducts which were present in five cases.

Case 1, 2- showed absence of the cystic duct.

Case 3- showed two large accessory hepatic ducts that opened into the gallbladder.

Case 4- showed a long cystic duct and it had a spiral course and entered the common duct on its posterior surface and rather low down. There was presence of aberrant hepatic duct of small calibre which entered the cystic duct.

Case 5- showed small hepatic ducts which entered the gallbladder and cystic duct carried the bile to the duodenum.

Senapati A et al.[20] reported two patients with double cystic duct. Gallbladder was normal in both the cases. The accessory cystic duct was draining into the right hepatic duct.

Hiatt et al.[21] (1994) reviewed the records of 1000 patients who underwent liver harvesting for orthotopic transplantation and studied arterial anatomy. They found normal pattern of hepatic artery in 75.7% cases. A replaced or accessory left hepatic artery originating from the left gastric artery was seen in 9.7% cases. A replaced or accessory right hepatic artery originating from the superior mesenteric artery was seen in 10.6% cases. In 2.3% the right hepatic artery arose from the superior mesenteric artery, and the left hepatic artery was a branch of the left gastric artery.

Decker GAG[22] in his book had mentioned that in over 90% of cases the hepatic artery arises from the celiac axis. But it may come from the superior mesenteric artery or from the aorta directly. He has described following variations in the bile duct-

1. The cystic duct usually joins the CHD to form the CBD within 2-5 cm of the upper border of the duodenum.
2. The union of CD and CHD can occur behind the duodenum or the pancreas.
3. Usually the CD joins the CHD on its right side. But it may join the front, back, or even the left side of the common hepatic duct by taking a spiral course behind it.
4. The cystic duct may be absent.

He has also mentioned that arterial anomalies are very common. The arterial anomalies described by him are as follows-

1. The right hepatic artery may pass in front of the common hepatic duct.
2. The cystic artery may pass in front of the common hepatic duct.
3. The right hepatic artery may arise from superior mesenteric artery.
4. An Acc. CA may exist, and arises from the right hepatic artery, the left hepatic artery, or some other branch of the hepatic trunk.

The gallbladder anomalies described by Decker GAG were-

1. Congenital absence of gallbladder (extremely rare).
2. The gallbladder may be septate.
3. The gallbladder may be double with a single CD or with separate cystic duct.
4. The Phrygian cap deformity is the common congenital abnormality of the GB.
5. The gallbladder may have a mesentery.
6. It may be present on the left of the falciform ligament, or it may be intrahepatic.

Lamah et al.[23] (1999) performed retrospective review of 2080 cases and found twelve (0.58%) surgically significant anatomical variations consisting of absent cystic duct (three cases), abnormal termination of cystic duct (two into the right hepatic

duct, and one into the left hepatic duct), one case of double cystic duct, and five cases of significant accessory bile ducts.

Carbajo et al.[24] (1999) analyzed 500 cases and diagnosed congenital gallbladder malformations in 1% of the cases. GB and CD agenesia was seen in 0.2% cases. Left lobule misplacement with insertion of the CD into the LHD was seen in 0.2% cases, GB hypoplasias were seen in 0.6% cases.

Jones et al.[25] (2001) carried out a study on 180 livers procured for transplantation and documented that the RHA took origin from the main trunk of the common hepatic artery in 75% instances, arose from the superior mesenteric artery in 18%, the gastroduodenal artery in 6% of cases, and right gastric artery or aorta in 3 instances.

Futara G et al.[26] (2001) investigated 110 subjects and observed that the RHA took origin from the HAP in 66.3% cases, the common hepatic artery in 18.2% cases, the superior mesenteric artery in 8.2% cases or the celiac trunk in 7.3% cases. Ten cases of accessory right hepatic artery were seen out of which Acc. RHA was originating from the SMA in 7 cases, gastroduodenal artery in 2 cases or the left hepatic artery in 1 case. The cystic artery mainly arose from the right hepatic artery (75.5%) but also took origin from the middle hepatic artery (12.7%), gastroduodenal artery (7.3%) or the left hepatic artery (4.5%). When the CA is to the left of the CHA at its origin (39.1%), it crossed from left to right anterior to the CHD (28.2%) or posterior to the duct (10.9%). There were 11 accessory cystic arteries which took origin from the right hepatic in 6 cases, the middle hepatic in 3 cases or the left hepatic arteries in 2 cases.

Covey et al.[27] (2002) studied 600 patients and found that 61.3% patients had the standard hepatic arterial anatomy. In 12.2% patients the RHA was replaced to the SMA, whereas in one patient the RHA was replaced to the right phrenic artery. Accessory RHA was seen in 2.5% patients: 11 accessory RHA originated from the SMA, and one each originated from the GDA, LGA, celiac axis, and right phrenic artery.

Peloponissios et al.[28] (2005) reported two cases of agenesis of gallbladder. They also reviewed the world literature and stated that the prevalence range of agenesis of gallbladder is 0.007-0.13%.

Harold Ellis[29] in his book Clinical Anatomy a revision and applied anatomy for clinical students had mentioned some variations in biliary anatomy-

(a) A long cystic duct joining the hepatic duct low down behind the duodenum.

(b) Absence of the cystic duct—the gallbladder opens directly into the CHD.

(c) A double gall-bladder.

(d) The right hepatic artery crosses in front of the common hepatic duct in 25% of cases.

Jinxing et al.[30] (2006) reported that low insertion of the cystic duct into distal common bile duct occurs in 9% of all individuals. An aberrant or accessory right hepatic biliary duct emptying into the common hepatic duct or cystic duct was seen in 7.4% of patients undergoing cholangiography.

Bayraktar et al.[31] (2006) reported a case of multiple congenital anomalies of the extrahepatic biliary tree associated with right portal vein thrombosis. The anomalies seen were absence of gallbladder, cystic duct and common bile duct together with the junction of the right and left hepatic ducts at the pancreatic head.

Ding et al.[4] (2007) undertook a retrospective evaluation of 600 non-emergency patients who underwent laparoscopic cholecystectomy for different gallbladder diseases. They found cystic artery passing through Calot's triangle in 85.5% patients. The cystic artery originating from the right hepatic artery within Calot's triangle was recorded in 73.3% patients. 12.2% patients were recorded to have double CA. CA originating from gastroduodenal artery was found in 7.5% patients in this study. CA originating from the variant right hepatic artery was found in 3% patients. CA originating directly from the liver parenchyma was found in 2.5% patients. In 1.5% patients they found that the cystic arteries exist not only in Calot's triangle, but also outside it.

Yun-Hua W et al.[32] (2008) highlighted two cases of anatomical variations of the cystic duct. Case 1 showed long cystic duct with low medial insertion into common bile duct. Case 2 showed a long cystic duct with a narrow and in-curved lumen, which was well separated from the gallbladder. The rest of the entire biliary tract was normal without calculi.

Alicioglu B[33] (2007) reported a case of triple gallbladder which was incidentally diagnosed in a patient with sigmoid diverticulitis. Each gallbladder was bearing a separate cystic duct which was joining separately with the common bile duct.

Khan AH et al.[3] (2008) studied 100 patients to identify various anomalies of the extra hepatic biliary tree seen during cholecystectomy and concluded that Moynihan's hump and accessory cystic artery were the most frequently found anomalies each in 6% cases, followed by double cystic duct in1% case and long cystic duct in 1% case.

Abeysuriya et al.[1] (2008) reported a case of extrahepatic biliary system with rare morphological anomalies which included intrahepatic union of the right and left hepatic ducts and the common hepatic duct drained directly into the gall bladder neck, with absence of the common bile duct. Further drainage of the bile away from the gallbladder and into the duodenum was provided by the cystic duct. The width and the length of the gall bladder were 2.5 cm and 4.5 cm respectively. The length of the CHD was 2.6 cm and that of the cystic duct was 6.9 cm. The CA was originating from the right hepatic artery. The right hepatic artery was found to be communicating with the left hepatic artery by a "bridging artery" after giving rise to the cystic artery. An accessory hepatic artery originated from the "bridging artery" forming a "cruciate" hepatic arterial anastomoses.

Vishnumaya et al.[34] (2008) in the routine dissection of a male cadaver observed a case of the CA having an origin from the GDA 2.5cm distal to the origin of CHA.

Borley NR[6] has mentioned that junction of CD with CHD usually occurs near the porta hepatis. Rarely, the cystic duct lies along the right edge of the lesser omentum all the way down to the level of the duodenum before the junction is formed. The cystic duct occasionally can be double.

The gallbladder varies in size and shape. The gallbladder may be bifid or completely duplicated, usually with a duplicated cystic duct.

Cystic artery can have variable origin from the common hepatic artery (most commonly), sometimes from the left hepatic or gastroduodenal artery, and rarely from the superior pancreaticoduodenal, celiac, right gastric or superior mesenteric arteries. In these cases, it crosses anterior (or less commonly posterior) to the common bile duct or common hepatic duct to reach the gallbladder. An accessory cystic artery may

arise from the common hepatic artery or one of its branches and the cystic artery often bifurcates close to its origin, giving rise to two vessels which approach the GB.

Snell RS[35] in his book Clinical anatomy by regions (2008) has mentioned about common variations of blood supply of gallbladder. The right hepatic artery can cross in front of common hepatic duct. The cystic artery can sometimes arise from common hepatic artery. He has also mentioned some common congenital anomalies of the gallbladder like congenital absence of gallbladder or double gallbladder. The cystic duct can be absent or abnormally long or there can be presence of accessory bile duct.

Moore KL[7] states that in most people the right hepatic artery runs posterior to common hepatic duct. The most common source of an aberrant right hepatic artery is the SMA.

Variations in biliary ducts described by him are-

1. The cystic duct may be short or even absent.
2. In some people there is low union of the cystic and common hepatic ducts. Occasionally there is high union of the CD and CHD near the porta hepatis.
3. In some cases the CD spirals anteriorly over the CHD and joins it on the left side.
4. Accessory hepatic ducts are commonly seen.

Moon et al.[36] (2009) reported a case of RHA branching off from the SMA and crossing posterior to the portal vein. This artery served as the sole arterial supply to the right lobe, and was identified as a replaced RHA.

George RA et al.[5] (2009) reported a case of low insertion of a cystic duct which resulted in the inadvertent placement of the common bile duct stent into the cystic duct. The cystic duct was elongated and followed a parallel course in its distal

aspect to join the CBD in the immediate supra pancreatic region.

Bakheit MA[37] studied 160 Sudanese people and found that the cystic artery originated from the right hepatic artery in 78% of cases, the common hepatic artery in 17% cases, the left hepatic artery in 2% cases and the gastroduodenal artery in 3% cases. Regarding the position of the cystic artery in Sudanese subjects the following results were obtained: at the Calot's triangle in 25% cases, anterior to the cystic duct in 53% cases, posterior to it in 13% cases, anterior to the common hepatic duct in 7% cases and anterior to the bile duct in 2% of cases.

Talpur et al.[38] (2010) studied 300 cases of cholelithiasis to assess the frequency of anatomical variations of extrahepatic biliary system in patients undergoing laparoscopic cholecystectomy. Operative findings revealed variations in 20.33% cases, mainly involving cystic artery in 10.67% cases, cystic duct in 4.33% cases, right hepatic artery in 2.67% cases, gall bladder in 2% cases and common hepatic artery in 0.67% cases. The GB anomalies were seen in 2% of patients in form of buried gallbladder in 1% case and floating gallbladder, Phrygian cap GB and gallbladder lying parallel to common bile duct each in 0.33% of cases. The cystic duct anomalies seen in this study were 4.33% in the form of short CD (2.67%), long CD (1%) with low insertion and accessory cholecystohepatic duct (0.67%). The vascular anomalies assessed in their study were seen in 14% cases out of which 2.67% revealed Moynihan's hump. The short cystic artery was seen in 1.67% of cases in this study. The variations in the course of CA found in this series were artery crossing anterior to cystic duct in 2.67%, posterior in 1.33% and right to cystic duct in 0.67% of cases. Double cystic artery was seen in 1% of case in this study. Aberrant cystic artery was seen in 2.33% of cases.

Blidaru et al.[39] (2010) concluded that common bile duct has an average length of 72.02 mm and an average diameter of 5.25 mm. The average length and the average diameter of the common bile duct are larger in males.

George BM et al.[40] (2010) during the regular demonstration classes encountered a liver with few sub hepatic vascular variations in a 53-year-old male cadaver. They saw an accessory left hepatic artery arising from HAP, which was branching and supplying the left hepatic lobe. There were 2 cystic arteries; both arose from hepatic artery proper just after the former gave rise to the accessory left hepatic artery.

Oddsdottir M et al.[41] mentioned that the classic description of the extrahepatic biliary tree and its arteries is seen in only about one third of patients. The gallbladder may have abnormal positions, may be intrahepatic, may be rudimentary, have anomalous forms, or be duplicated. Isolated congenital absence of the gallbladder is very rare with a reported incidence of 0.03%. Duplication of the gallbladder with two separate cavities and two separate cystic ducts has an incidence of about one in every 4000 persons.

He has reported following variations of cystic duct anatomy-

a. Low junction between the cystic duct and common hepatic duct.
b. High junction between the cystic duct and common hepatic duct.
c. Cystic duct drains into right hepatic duct.
d. Long cystic duct that joins common hepatic duct behind the duodenum.
e. Absence of cystic duct.
f. Cystic duct crosses posterior to common hepatic duct and joins it anteriorly.
g. Cystic duct crosses anterior to common hepatic duct and joins it posteriorly.

He also reported that anomalies of hepatic and the cystic artery occur in as many as 50% of cases. In about 5% of cases there are two right hepatic arteries, one from the common hepatic artery and the other from the superior mesenteric artery. In about 20% of patients the right hepatic artery comes off the superior mesenteric artery. It may course anterior to the common duct. The cystic artery arises from the right hepatic artery in about 90% of cases, but may also arise from the LHA, CHA, GDA, or SMA.

Bhardwaj N[42] observed that RHA took origin from proper hepatic artery in 65% cases, the CHA in 20% of cases, the SMA in 8.3% of cases or celiac trunk in 6.6% of cases. 3 cases of accessory RHA were seen which originated from SMA in 1.7% cases and GDA in 3.3% cases.

The cystic artery mainly arose from the RHA in 75% cases, middle hepatic artery in 13.3% cases, GDA in 6.7% cases or the LHA in 5% cases. Cystic artery passed in the Calot's triangle in 48 cases. There were 6 accessory cystic artery arising from the RHA (3cases), the middle HA (2 cases) or the LHA (1 case).

Gupta et al.[43] (2010) reported a case of double gallbladder with two separate cystic ducts opening into the common bile duct.

Pushpalatha et al.[44] (2010) observed that the cystic artery was arising from RHA in 54% cases, HAP in 22% cases, CHA in 12% cases, GDA in 8% cases, SMA in 2% cases, and accessory hepatic artery in 2% cases.

Shih YJ et al.[45] reported a case of a man with a double cystic duct that was detected during elective laparoscopic cholecystectomy.

Cachoeira et al.[46] (2012) analyzed 41 cadavers and found that the length of the CHD varied between 4.18 mm and 50.64 mm, with an average of 21.76 ± 9.51 mm. The length of the CD varied between 7.28 and 38.88 mm, with an average of 19.11 ± 6.77 mm.

Khan et al.[47] (2012) studied 300 patients who underwent open cholecystectomy and found normal anatomy in 72% patients. Short cystic duct (2.33%) was the most common variation observed in his study. Other variations seen were-

1. Long cystic duct in 5 cases (1.66%).
2. Cystic duct arising from right hepatic duct in 5 cases (1.66%).
3. Double cystic duct in 4 cases (1.33%).

Thus overall frequency of the cystic duct variants in this study was 8.33%.

Gupta et al.[48] (2012) studied 150 cadavers to detect anomalies of gallbladder and associated structures and observed that-

1. Double gallbladder was seen in 2% cases.
2. GB was extrahepatic in position in 99.3% cases and intrahepatic in 0.7% case.
3. Type of termination of the cystic duct into common hepatic duct was angular in 70% cases, spiral in 8%, and parallel in 22% cases.
4. Length of cystic duct was 3-4 cm.
5. Cystic duct was single in 97.3% cases and double in 2.7% cases.
6. 14% cases had double cystic arteries.
7. Cystic artery was arising from RHA in 98% cases and from GDA in 2% cases.

Bergman et al.[49] in anatomy atlases.org (accessed on July 2013) had reported a case of duplication of common bile duct.

MATERIALS AND METHODS

SOURCE OF DATA:

The study of variations of extrahepatic biliary apparatus was conducted on 20 specimens. The specimens were obtained from cadavers of Department of Anatomy of BLDEU's Shri B.M. Patil medical college Bijapur.

METHOD OF DATA COLLECTION:

Sample size: It was a time bound study, 20 samples were studied.

METHODOLOGY:

Cadavers were studied from dissection room of Anatomy department. Dissection was carried out by taking a midline incision from xiphisternum to pubic symphysis and then this incision was extended from pubic symphysis to anterior superior iliac spine. Skin and fascia was reflected laterally. Rectus muscle was cut open in the midline. Peritoneum was opened and entered into the abdominal cavity. Stomach was identified and its curvatures were defined. By pulling the lesser curvature, lesser omentum was identified and its right free margin was defined and then hepatoduodenal ligament was identified. Now the greater omentum was cut transversely below it and was pushed forwards towards right. Coils of small intestine were pushed towards left and 2nd part of duodenum was exposed. Stomach was reflected to expose the pancreas.

The hepatoduodenal ligament was opened by tracing the bile duct upwards and the point where the cystic duct and common hepatic duct unites was identified. Cystic duct was traced upwards up to the neck of gall bladder. The gall bladder was looked for its number, position, peritoneal relations, shape, dimensions and distance from inferior border of liver.

Common hepatic duct was then traced upwards to locate the right and left duct emerging from porta hepatis. Lateral to the duct system towards left the CHA was identified and traced upwards where it divides into right and left hepatic arteries. From the right hepatic artery, cystic artery was identified and traced. The boundaries of Calot's triangle were defined and the cystic artery inside the triangle was traced up to gall bladder. Posterior to all above structures, the portal vein was defined. During the above procedure, the mode of formation of the duct system, the course and arrangement of the ducts, the mode of termination along with related vessels were studied. Then the length of the individual ducts was measured.

Observation was recorded in prepared proforma. Later ducts were painted with green acrylic paint and artery with red acrylic paint in order to make them bold and photographs were taken.

Two ligatures were put, one at the pyloric end of stomach and second just below 2nd part of duodenum and that part of duodenum was incised. Pancreas was cut at the level of neck. This makes the visceral surface of liver, free along with 2nd part of duodenum and head of pancreas. The ribs were cut open along the costo-chondral junction of both sides and reflected upwards along with sternum, to make the parietal surface of liver free. Inferior vena cava identified and cut, and now the liver along with extrahepatic biliary apparatus, duodenum and head of pancreas was removed in total. Specimens were preserved in 5% formalin.

MATERIALS USED:

Scalpel, blunt, toothed and pointed forceps, scissors, thread, red and green acrylic paint and paint brush, measuring tape and scale.

INCLUSION CRITERION:

Specimens of the extra hepatic biliary apparatus along with second part of duodenum and head of pancreas were taken.

EXCLUSION CRITERION:

- Specimen of above organ with pathology.
- Specimen without any of the above organ.

STATISTICAL ANALYSIS:

Data was analysed using the following statistical methods.

- Diagrammatic presentation.
- Mean ± Standard deviation.
- Percentages.

Study was carried out for a period of one and half years from Nov 2011 to April 2013.

Other related terms used during collection of information

Phrygian cap = The fundus is folded back upon the body of the gallbladder. This is called as Phrygian cap. [6]

Hartmann's pouch = The neck of gallbladder may widen out and this widening is often referred to in clinical practice as Hartmann's pouch. [6]

Accessory artery = An accessory artery is a vessel that supplies a lobe in addition to its normal vessel. [6]

Replaced hepatic artery = Replaced hepatic artery is a vessel that does not originate from an orthodox position and provides the sole supply to the lobe. [6]

Aberrant artery = It includes both accessory and replaced artery.

Reference citing: Vancouver style is used for listing and citing of references. References are numbered according to their appearances in the text and listed accordingly.

OBSERVATIONS AND RESULTS

The observations made after dissecting 20 adult human cadavers were as follows-

1. **Gall bladder :**

The gall bladder showed following features in this study-

The gall bladder was single in all the specimens. It was present in the fossa for gall bladder over the inferior surface of right lobe of liver. The inferior surface was covered by peritoneum in all the samples. Mesentery was not present in any of the specimen. The gall bladder was normal in shape in 19 specimens. Hartman's pouch over neck was seen in 1 specimen. The fundus, body was normal in all specimens. The fundus was noted at different levels from the inferior border of liver.

Table No.1: Length of gallbladder

Length of gallbladder in cm	Frequency
4	1
4.5	1
5	1
5.5	1
6	4
6.5	3
7	4
7.5	1
8	1
9	2
9.5	1

The above table shows frequency wise distribution of length of gallbladder which varied from a minimum of 4 cm to the maximum of 9.5 cm and the average length of gallbladder was 6.68±1.44 cm.

Table No.2: Width of gallbladder

Width of gallbladder in cm	Frequency
2	4
2.5	5
3	5
3.4	1
3.5	2
4	3

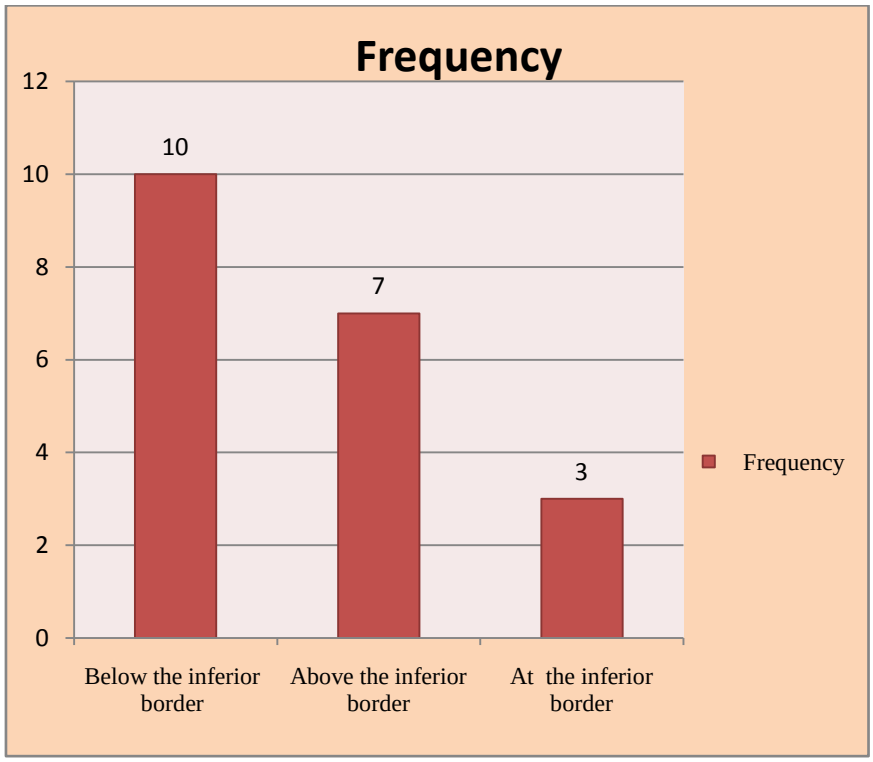
The above table shows frequency wise distribution of width of gallbladder which varied from a minimum of 2 cm to the maximum of 4 cm and the average width of gallbladder was 2.89±0.68 cm.

Table No.3: Position of fundus of gallbladder

Position of fundus of gallbladder from inferior border of liver	Frequency	Percentage
Below the inferior border	10	50%
Above the inferior border	7	35%
At the inferior border	3	15%

The above table shows frequency and percentage wise distribution of position of fundus of gallbladder which shows most commonly it was below the inferior border of liver (50%) and least common location was at the inferior border of liver (15%).

Graph no.1: Position of fundus of gallbladder



1. Cystic duct:

The cystic duct showed following features in this study –

[A**] Number and length --** In all the 20 specimens cystic duct was single. Length of cystic duct which was observed is shown in table no.7.

[B] Type of termination of cystic duct:-

There are 3 types of termination of cystic duct

a] Angular type: In this cystic duct makes an angle to join with the common hepatic duct. This type of union was observed in 19 out of 20 specimens (95%). In all the specimens cystic duct united with common hepatic duct from its right side.

b] Parallel type: In this type cystic duct runs parallel to the common hepatic duct for varying distance before uniting with it. In the present study 1 out of 20 specimens (5%) showed parallel union (Specimen no-6).

c] Spiral type: In this type cystic duct makes a spiral course before joining with the common hepatic duct either on the anterolateral or posterolateral side. No such finding was observed in the present study.

Table No.4: Type of termination of cystic duct

Type of termination	Frequency	Percentage
Angular Type	19	95%
Parallel Type	1	5%
Spiral Type	0	0

The above table shows frequency and percentage wise distribution of type of termination of cystic duct which shows that angular type was most common. It was seen in 95% specimens. Parallel type was seen in 5% specimens and spiral type was not observed. The cystic duct joined the common hepatic duct from right side in all the specimens.

[C] Level of termination of cystic duct- the cystic duct joins the common hepatic duct either at the high level, normal level or low level.

a] High level of union- in this CD joins with the CHD into the region of common hepatic duct bifurcation. In this the length of the CHD will be shorter and that of CBD will be longer. In present study high level of union was seen in 4 specimens (20%). (Specimen no.- 1, 2, 7, 16.)

b] Normal level of union- in this CD joins the extra hepatic bile duct approximately halfway between the porta hepatis and the ampulla of Vater. This type of union was seen in 13 out of total 20 specimens (65%).

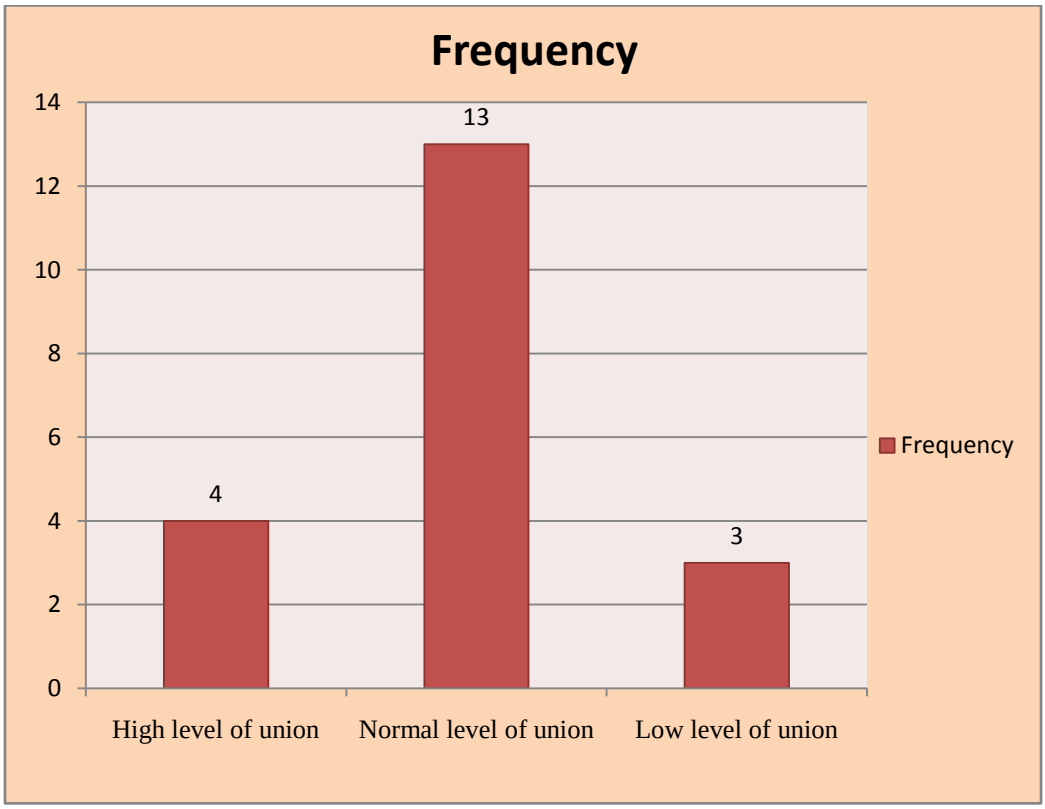
c] Low level of union- in this cystic duct fuses with the distal third of extrahepatic bile duct. This type of union was seen in 3 specimens (15%). (Specimen no. 4, 11, 15)

Table No.5: Level of termination of cystic duct

Level of termination	Frequency	Percentage
High level of union	4	20%
Normal level of union	13	65%
Low level of union	3	15%

The above table shows frequency and percentage wise distribution of level of termination of cystic duct which shows, normal level of union was most commonly observed (65%), high level of union in 20% specimens and low level of union in 15% specimens.

Graph no.2: Level of termination of cystic duct



3. Common hepatic duct:

The common hepatic duct showed following features in this study:

[A] Number and length-Common hepatic duct was single in all the specimens. Length of common hepatic duct which was observed is shown in table no.7.

[B]Formation of common hepatic duct:

a] By extrahepatic union of right and left hepatic ducts - formation of common hepatic duct by union of right and left hepatic ducts outside the porta hepatis was seen in 12 (60%) of specimens.

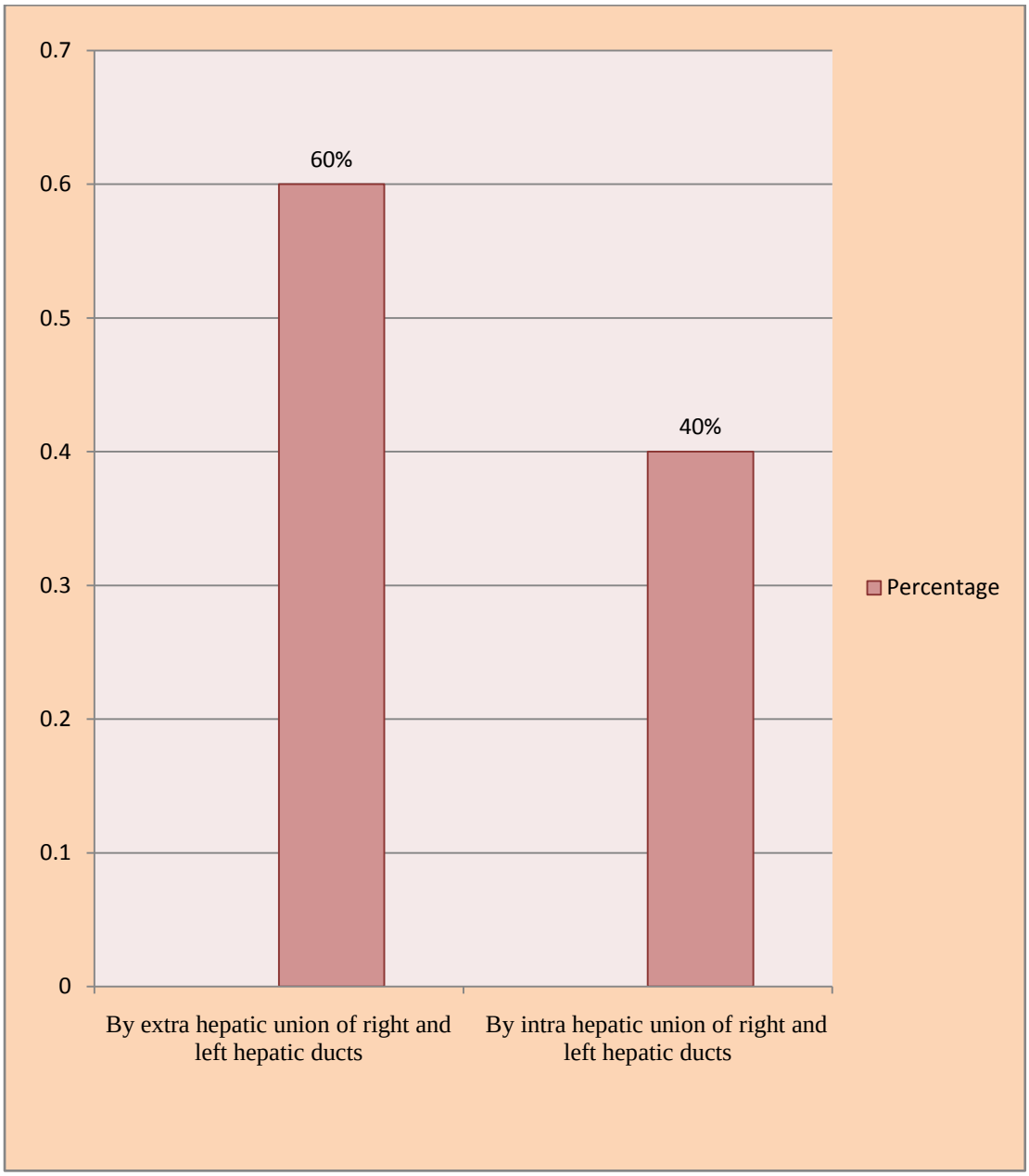
b] By intrahepatic union of right and left hepatic ducts -formation of common hepatic duct by union of right and left hepatic ducts intrahepatically was seen in 8 (40%) of specimens.

Table No.6: Formation of common hepatic duct

Formation of common hepatic duct	Frequency	Percentage
By extrahepatic union of right and left hepatic ducts	12	60%
By intrahepatic union of right and left hepatic ducts	8	40%

The above table shows frequency and percentage wise distribution of formation of common hepatic duct which shows extrahepatic union was observed in 60% of specimens and intrahepatic union was observed in 40% of specimens.

Graph no.3: Formation of common hepatic duct



4. Common bile duct:

The common bile duct showed following features in this study:-

Number and length -- Common bile duct was single in all the specimens. Length of common bile duct which was observed is shown in table no 7.

Table No.7: Length of Biliary ducts

Specimen No.	Length of cystic duct in cms	Length of common hepatic duct in cms	Length of common bile duct in cms
1	2	1.5	6
2	2.5	1.5	5.5
3	3	2.5	5
4	2.5	5	3
5	2	2	4
6	1.5	2.5	5.5
7	1.2	1.8	6.5
8	2	3	6.5
9	1.5	2.5	6
10	3	2.5	6
11	3.5	4	4.5
12	2	3	6
13	2.5	3	5
14	2.5	4	8
15	3	5	3.5
16	1.5	1.5	7
17	2.5	3	6.5
18	2	3	6.5
19	2	3	6
20	2.5	3.5	7

The above table shows that the length of cystic duct varied from 1.2 cm to 3.5 cm and the average length was 2.26±0.59 cm. The length of common hepatic duct varied from 1.5 cm to 5 cm and the average length was 2.89±1.03 cm. The length of common bile duct varied from 3 cm to 8 cm and the average length was 5.7±1.23 cm..

5. Variation in the ductal system:

In the present study accessory cystic ducts were found in 2 (10%) out of 20 specimens.

Details of accessory cystic ducts are as follows:-

Specimen no 15:- showed single accessory cystic duct of length 2.5 cm which was extending from body of gallbladder to common hepatic duct.

Specimen no 16:- showed single accessory cystic duct of length 1 cm which was extending from body of gallbladder to right hepatic duct.

6. **Variation in arteries related to extra hepatic biliary system:-**

The arteries related to extra hepatic biliary system are cystic artery and right hepatic artery. The variations observed in these arteries in the present study are as follows-

Specimen no. 2- Common hepatic artery was dividing into right hepatic artery, left hepatic artery and accessory right hepatic artery. Right hepatic artery was giving CA to the left of common hepatic duct outside the Calot's triangle. CA was entering the Calot's triangle by crossing common hepatic duct anteriorly and it was supplying gallbladder. Accessory right hepatic artery was crossing common bile duct anteriorly and then was entering into the Calot's triangle by passing deep to cystic duct. Acc. CA was arising from accessory right hepatic artery near the cystic duct and was supplying the superficial surface of gallbladder.

Specimen no. 3- Two cystic arteries were present. CA was arising from right hepatic artery inside the Calot's triangle and supplied both surfaces of gallbladder. Acc. CA

was arising from posterior superior pancreaticoduodenal artery to the left of common bile duct and was crossing it anteriorly and supplied superficial surface of gallbladder. Both right and left hepatic arteries were arising from common hepatic artery.

Specimen no. 5- Right hepatic artery was arising from hepatic artery proper then it crossed the common hepatic duct anteriorly (instead of crossing it posteriorly) and entered the Calot's triangle. Cystic artery was arising from right hepatic artery.

Specimen no.7- Showed presence of replaced right hepatic artery. This artery was arising from superior mesenteric artery. This right hepatic artery was crossing behind the bile duct and portal vein and then entered the Calot's triangle by passing deep to cystic duct. Cystic artery was arising from right hepatic artery.

Specimen no.8- Right hepatic artery was arising from hepatic artery proper then it crossed the common hepatic duct anteriorly (instead of crossing it posteriorly) and entered the Calot's triangle. Cystic artery was arising from right hepatic artery.

Specimen no.10- Showed two right hepatic arteries. Both were arising from hepatic artery proper. Right hepatic artery crossed the common hepatic duct posteriorly and entered the Calot's triangle. Accessory right hepatic artery crossed the common hepatic duct anteriorly and entered the Calot's triangle. Cystic artery was arising from accessory right hepatic artery.

Specimen no.11- Showed right hepatic artery was a branch from common hepatic artery. Cystic artery was arising from right hepatic artery to the left of common hepatic duct and crossed it anteriorly to enter into the Calot's triangle.

Specimen no. 12- CA was arising from right hepatic artery in Calot's triangle and was supplying superficial and deep surface of gallbladder. Accessory CA was arising

from middle hepatic artery outside the calot's triangle to the left of common hepatic duct. It crossed common hepatic duct anteriorly, entered the Calot's triangle and was supplying the superficial surface of gallbladder.

Specimen no. 16- Showed presence of replaced right hepatic artery. This artery was a branch from superior mesenteric artery. It was running behind the common bile duct and portal vein and gave rise to cystic artery in the Calot's triangle.

Specimen no. 19- Showed that right hepatic, left hepatic and gastroduodenal arteries were branch from common hepatic artery.

Specimen no.20- Showed two cystic arteries. CA was arising from right hepatic artery on the left side of common hepatic duct. CA crossed the common hepatic duct anteriorly, entered the Calot's triangle and supplied the gallbladder. Accessory right hepatic artery was arising from superior mesenteric artery. It was running behind the portal vein and common bile duct. Acc. CA was arising from this accessory right hepatic artery and was supplying the deep surface of gallbladder.

Table No.8: Origin of Right hepatic artery

Right hepatic artery origin from	Frequency	Percentage
Hepatic artery proper	14	70%
Common hepatic artery	4	20%
Superior mesenteric artery	2	10%

The above table shows frequency and percentage wise distribution of origin of right hepatic artery. Right hepatic artery was arising from hepatic artery proper in 70% specimens (most common), from common hepatic artery in 20% specimens and least commonly from superior mesenteric artery in 10% specimens.

Graph No 4: Origin of Right hepatic artery

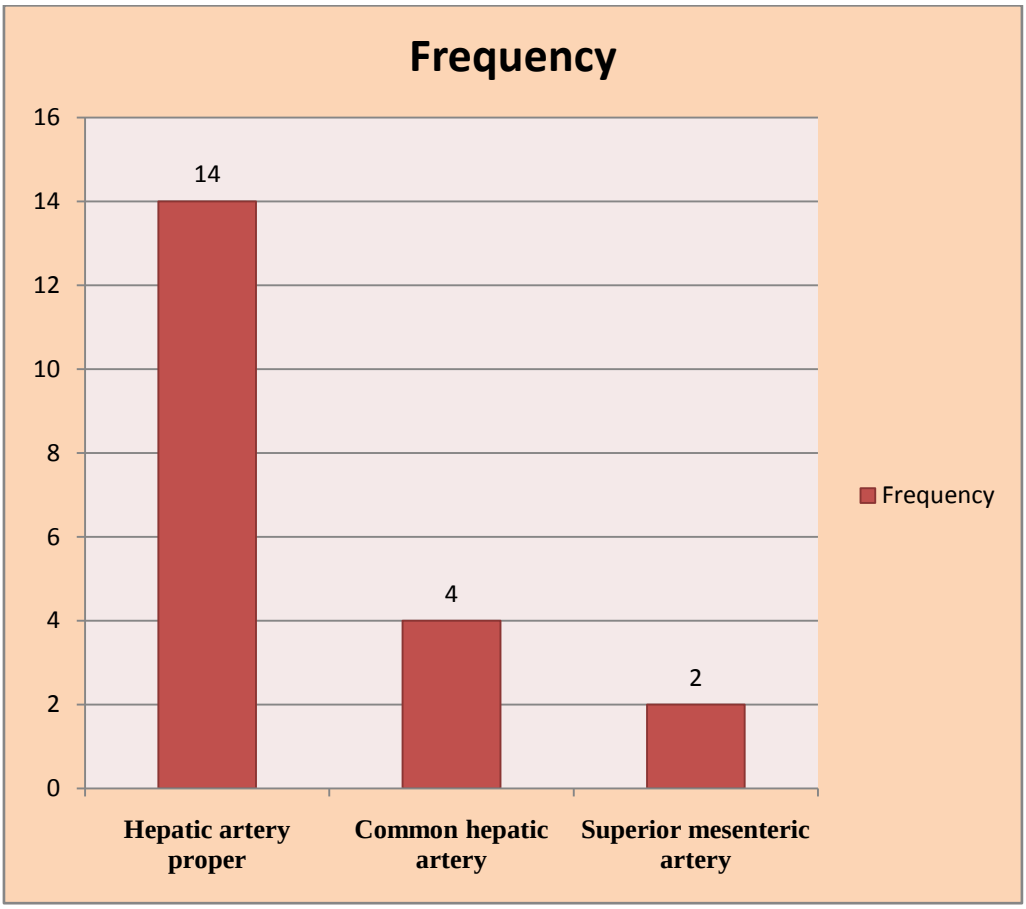


Table No.9: Origin of Cystic artery

Cystic artery origin from	Frequency	Percentage
Right hepatic artery	17	85%
Aberrant right hepatic artery	3	15%

The above table shows frequency and percentage wise distribution of origin of cystic artery. Cystic artery had origin from right hepatic artery in 85% specimens (most common) and least commonly from aberrant right hepatic artery in 15% specimens.

Graph No 5: Origin of Cystic artery

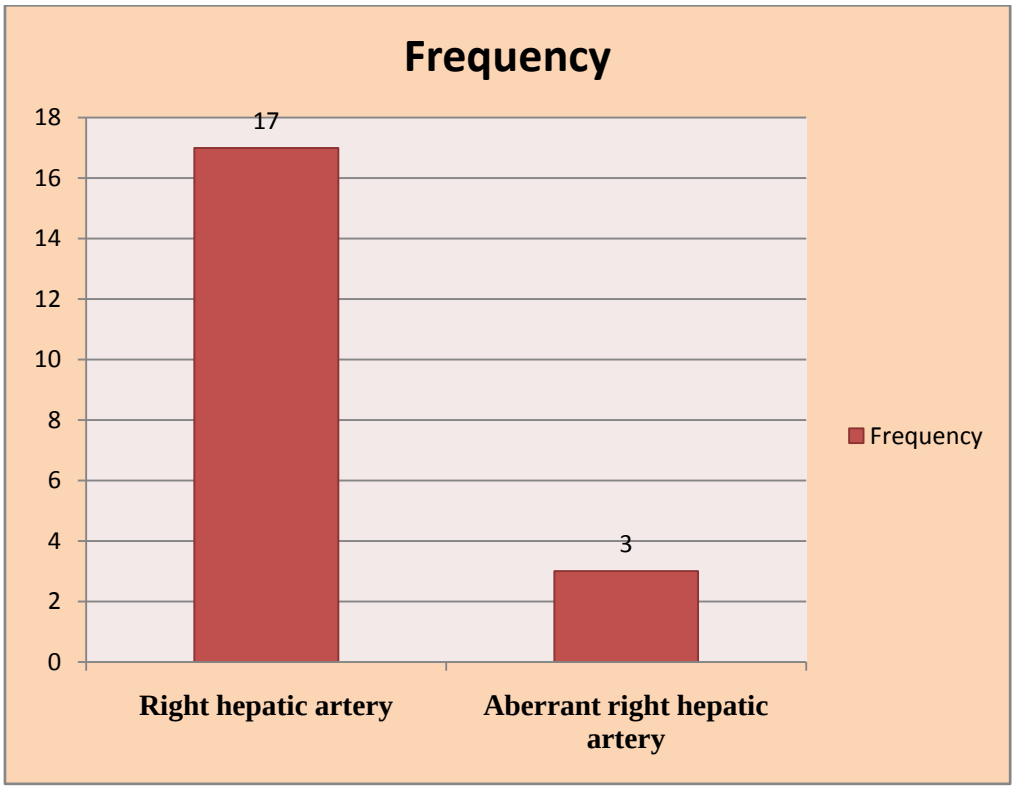


Table No.10: Origin of Accessory right hepatic artery

Accessory right hepatic artery origin from	Frequency	Percentage
Hepatic artery proper	1	33.33%
Common hepatic artery	1	33.33%
Superior mesenteric artery	1	33.33%

The above table shows frequency and percentage wise distribution of origin of accessory right hepatic artery. Accessory right hepatic artery was observed in 3 specimens out of 20 (specimen no.- 2, 10, 20) Accessory right hepatic artery had origin from hepatic artery proper, common hepatic artery and from superior mesenteric artery in 1specimen each.

Table No.11: Origin of Accessory cystic artery

Accessory Cystic artery origin from	Frequency	Percentage
Accessory Right hepatic artery	2	50%
Posterior superior pancreaticoduodenal artery	1	25%
Middle hepatic artery	1	25%

The above table shows frequency and percentage wise distribution of origin of accessory cystic artery. Accessory cystic artery was observed in 4 specimens out of 20 (specimen no.- 2, 3, 12, 20). Accessory cystic artery had origin from accessory right hepatic artery in 2 specimens, from posterior superior pancreaticoduodenal artery in 1 specimen and from middle hepatic artery in 1 specimen.

Table No.12: Relation of Right hepatic artery to common hepatic duct

Right hepatic artery crossing CHD	Frequency	Percentage
Anteriorly	2	10%
Posteriorly	16	80%
Not crossing	2	10%

The above table shows that right hepatic artery crossed common hepatic duct posteriorly in 80% specimens, crossed common hepatic duct anteriorly in 10% specimens and did not crossed common hepatic duct in 10% specimens.

Replaced right hepatic artery which had origin from superior mesenteric artery did not crossed common hepatic duct.

Table No.13: Relation of Cystic artery to common hepatic duct

Cystic artery crossing CHD	Frequency	Percentage
Anteriorly	5	25%
Posteriorly	15	75%

The above table shows that cystic artery crosses common hepatic duct posteriorly in 75% specimens and crosses common hepatic duct anteriorly in 25% specimens

7. CALOT'S TRIANGLE:

A] Boundaries- The boundaries of Calot's triangle were normal in all the 20 specimens.

B] Content- Content was normal in 13 out of 20 specimens (65%). In the rest 7 specimens (35%) following variations were observed apart from normal contents-

1. Presence of accessory right hepatic artery in specimen no. 2.

2. Presence of accessory cystic artery in specimen no. 3.

3. Presence of accessory right hepatic artery in specimen no.10.

4. Presence of accessory cystic artery in specimen no.12.

5. Presence of accessory cystic duct in specimen no.15.

6. Presence of accessory cystic duct in specimen no.16.

7. Presence of cystic artery, accessory cystic artery and accessory right hepatic artery was observed in specimen no. 20. RHA was not a content of Calot's triangle.

8. Other variations found in the present study:-

Specimen no. 2- right gastric artery and gastroduodenal arteries were arising from accessory right hepatic artery. Accessory left hepatic artery was present and it was a branch from left gastric artery.

Specimen no. 4- hepatic artery proper was dividing into right hepatic artery, posterior superior pancreaticoduodenal artery and a common trunk which was further dividing into left hepatic artery and right gastric artery. Middle hepatic artery was seen to be arising from right hepatic artery.

Specimen no.5- showed that hepatic artery proper was dividing into left hepatic artery, right hepatic artery, posterior superior pancreaticoduodenal artery and a common trunk which was further dividing into middle hepatic artery and right gastric artery.

Specimen no. 6- middle hepatic artery was present and it was a branch from right hepatic artery.

Specimen no. 7- middle hepatic artery was present and it was a branch from left hepatic artery.

Specimen no. 9- middle hepatic artery was present and it was a branch from left hepatic artery.

Specimen no. 10- showed a common trunk (hepatosplenomesenteric trunk), which was arising from abdominal aorta. It was giving rise to common hepatic artery, splenic artery and superior mesenteric artery. Celiac trunk was absent. Left hepatic artery was arising from left gastric artery.

Specimen no. 11- middle hepatic artery was present. It was a branch from right hepatic artery.

Specimen no. 12- hepatic artery proper was dividing into left hepatic artery, right hepatic artery and a common trunk. This common trunk which was further dividing into middle hepatic artery and accessory left hepatic artery and posterior superior pancreaticoduodenal artery.

Specimen no. 13- middle hepatic artery was present. It was a branch from right hepatic artery.

Specimen no. 14- showed accessory left hepatic artery arising from left gastric artery. It also showed accessory right gastric arteries arising from right hepatic artery.

Specimen no. 16- hepatic artery proper was terminating by dividing into middle hepatic artery and two left hepatic arteries.

Specimen no. 17- showed middle hepatic artery arising from right hepatic artery.

Specimen no. 19- right gastric artery was a branch from left hepatic artery. Middle hepatic artery was arising from right hepatic artery.

Specimen no. 20- left hepatic artery was a branch from left gastric artery.

KEY TO PHOTOGRAPH

1 –Common hepatic artery

2 – Proper hepatic artery

3 – Right hepatic artery

4 – Left hepatic artery

5 – Cystic artery

6 –Gastroduodenal artery

7 –Right gastric artery

8 –Common hepatic duct

9 – Cystic duct

10– Common bile duct

11- Gallbladder

12- Left gastric artery

13- Accessory right artery

14- Accessory cystic artery

15- Middle hepatic artery

16- Posterior superior pancreaticoduodenal artery

17- Superior mesenteric artery

18- Accessory cystic duct

19- Accessory left hepatic artery

20- Hartman's pouch

DISCUSSION

Operative procedures are frequently performed for disturbances in the function of the extrahepatic biliary tract. In the available literature many cases are reported of injuries to the biliary tract during operation on subjects in whom the arrangement of the biliary tract was atypical. A sound knowledge of the normal anatomy of the extrahepatic biliary tract and also of congenital variation of biliary and vascular anatomy is thus essential in the prevention of operative injury to it.

In the present study 20 specimens were studied for the variations of extrahepatic biliary apparatus and the findings of the study have been compared with those of previous studies.

1. Gallbladder

Number-

In present study gallbladder was found to be single in all the specimens.

Harold Ellis[29], Borley NR[6], Moore KL[7], Oddsdottir M et al.[41] had mentioned that gall bladder is single normally. The present study is consistent with them.

Gupta et al.[48] (2012) observed double gallbladder in 2% cases. The present study is not consistent with them.

The anomalies like absent gallbladder, double gallbladder or triple gallbladder reported by various authors- Bergman[11], Decker GAG[22], Carbajo et al.[24], Peloponissios et al.[28], Bayraktar et al.[31], Alicioglu B[33], Snell RS[35], Gupta et al.[43] were not found in present study.

Position-

In the present study gallbladder was present in the fossa for gall bladder over the inferior surface of right lobe of liver in all the specimens.

Snell RS[35], Moore KL[7] had mentioned that gall bladder lies in the fossa for gall bladder over the inferior surface of right lobe of liver. The present study is consistent with these authors.

Lurje[16] studied 194 cadavers and found left sided gallbladder in 1.03% cases. The present study is not consistent with him.

Talpur et al.[38] (2010) studied 300 cases and found buried GB in 2% of patients. The present study is not consistent with them.

Oddsdottir M et al.[41] had reported about presence of left sided gallbladder or a retro displacement of the gallbladder. The present study is not consistent with them.

Peritoneal relations-

In the present study inferior surface of gallbladder was covered by peritoneum in all the samples.

Moore KL [7], Decker GAG[22] and Snell RS[35] had mentioned that normally inferior surface of gallbladder is covered by peritoneum. The present study is consistent with them.

Talpur et al.[38] (2010) found floating gallbladder due to mesentery in 0.33% of cases. The present study is not consistent with them.

Shape of gallbladder-

In the present study the gall bladder was normal in shape in 19 specimens and Hartman's pouch was seen in 1 specimen.

Snell RS[35], Moore KL[7], Oddsdottir M et al.[41] had mentioned that gallbladder is pear shaped. The present study is consistent with these authors.

Decker GAG[22] has mentioned that the folded fundus (Phrygian cap) deformity is the common congenital abnormality of the gallbladder. The present study is not consistent with him.

Talpur et al.[38] (2010) reported phrygian cap gallbladder in 0.33% of cases. The present study is not consistent with them.

Position of fundus of gallbladder-

In the present study fundus of gallbladder was below the inferior border of liver in 50% specimens, above the inferior border of liver in 35% specimens and at the level of inferior border of liver in 15% specimens.

Table No.14: Comparison of position of fundus of gallbladder from inferior border of liver in different studies

Position of fundus of gallbladder from inferior border of liver	**Lurje (1937)**	**Present study**
Below the inferior border	**53.1%**	**50%**
Above the inferior border	33%	35%
At the level of inferior border	13.9%	15%

The present study is similar to Lurje[16] study as he also found the most common position of fundus of gallbladder is below the inferior border of liver.

Decker GAG[22], Snell RS[35], Moore KL[7], Oddsdottir M et al.[41] had also mentioned that fundus usually projects from the inferior border of liver at the tip of the right 9th costal cartilage.

Dimensions of gallbladder-

In the present study the length of gallbladder varied from a minimum of 4 cm to the maximum of 9.5 cm and the average length of gallbladder was 6.68±1.44 cm. The width of gallbladder varied from a minimum of 2 cm to the maximum of 4 cm and the average width of gallbladder was 2.89±0.68 cm.

Borley NR[6], Decker GAG[22], Snell RS[35], Oddsdottir M et al.[41] had mentioned that in the adult the gallbladder is between 7 and 10 cm long.

2. Cystic duct :

Number

In the present study cystic duct was single in all the specimens.

According to Borley NR[6], Snell RS [35], Harold Ellis[29], Bayraktar et al.[31], Moore KL [7], Decker GAG[22], Oddsdottir M et al.[41] the cystic duct normally is single. The present study is consistent with them.

Toufeeq AK[18] (1953) studied fifty cases of cholecystectomy and found absent cystic duct in 12% cases. The present study is not consistent with him.

Carbajo et al.[24] (1999) reported absent cystic duct in 0.2% cases. . The present study is not consistent with them.

Anomalies like double or absent cystic duct reported by various authors- Khan et al.[3], Khan et al.[47], Lamah et al.[23] was not observed in present study.

Type of termination of cystic duct

Table No.15: Comparison of type of termination of cystic duct in different studies.

Authors	Angular	Parallel	Spiral
Eisendrath[13] (1918)	75%	17%	8%
Beaver[14] (1929)	58%	33.3%	12.3%
Thompson[15]	45%	3%	2%
Lurje[16] (1937)	46.9%	30.9%	22.2%
Gupta et al.[48] (2012)	70%	22%	8%
Present study	95%	5%	Nil

In the present study type of termination of cystic duct was angular type in 95% specimens (most common), parallel type was seen in 5% specimens and spiral type was not observed. The cystic duct joined the common hepatic duct from right side in all the specimens.

The present study is consistent with the findings of- Eisendrath[13], Beaver[14], Thompson[15], Lurje[16], Gupta et al.[48] as they also found most common type of termination of cystic duct was angular type.

Decker GAG[22], Moore KL[7] had mentioned that usually the cystic duct joins the common hepatic duct on its right side. The present study is consistent with them.

Toufeeq AK[18] (1953) found that the cystic duct joined the common hepatic duct on its left in 12% cases. The present study is not consistent with him.

Level of termination of cystic duct

In the present study normal level of union was seen in 65% specimens (most common), high level of union in 20% specimens and low level in 15% specimens (least common).

Lurje[16] (1937) studied 194 cadavers and observed that cystic duct joined the common hepatic duct at normal level in 66% cases (most common) and low insertion was seen in 34% cases (least common). The present study is consistent with him.

Jinxing et al.[30] (2006) reported that low insertion of the cystic duct into distal common bile duct occurs in 9% of all individuals. The present study is not consistent with them.

Talpur et al.[38] (2010) studied 300 cases and found long cystic duct with low insertion in 1% cases. The present study is not consistent with them.

3. Common hepatic duct

In the present study formation of common hepatic duct by union of right and left hepatic ducts outside the porta hepatis was seen in 60% of specimens and union of right and left hepatic ducts intrahepatically was seen in 40% of specimens.

Table No.16: Comparison of formation of common hepatic duct in different studies

Authors	Extrahepatic union of right and left hepatic ducts	Intrahepatic union of right and left hepatic ducts
Eisendrath[13]	100%	0%
Thompson[15]	90%	10%
Present study	60%	40%

The present study is similar to above studies as extrahepatic union of right and left hepatic ducts is most common and intrahepatic union is least common in all of these studies.

4. Common bile duct:

Number-

In the present study common bile duct was single in all the specimens.

Decker GAG[22], Borley NR[6], Snell RS [35], Moore KL[7], Oddsdottir M et al.[41] had mentioned that common bile duct is single. The present study is consistent with the above authors.

Variations like absent CBD or duplication of CBD reported by Bayraktar et al.[31] and Bergman et al.[49] were not observed in present study.

Length of Biliary ducts:

In the present study the length of cystic duct varied from 1.2 cm to 3.5 cm and the average length was 2.26±0.59 cm. The length of common hepatic duct varied from 1.5 cm to 5 cm and the average length was 2.89±1.03 cm. The length of common bile duct varied from 3 cm to 8 cm and the average length was 5.7±1.23 cm.

Decker GAG[22] had mentioned that CBD is usually 5 to 15 cm long.

Snell RS [35] had mentioned that common hepatic duct is about 4 cm long and common bile duct is usually 8 cm long.

Moore KL[7] had mentioned that common bile duct is usually 5 to 15 cm long and the length of cystic duct varies from 3- 4 cm.

Blidaru et al.[39] (2010) performed a study on 150 adult dissected corpses of both sexes and 22 human foetuses and concluded that common bile duct has an average length of 7.2 cm.

Cachoeira et al.[46] (2012) found that the length of the common hepatic duct varied between 4.18 mm and 50.64 mm, with an average of 21.76 ± 9.51 mm. The length of the cystic duct varied between 7.28 and 38.88 mm, with an average of 19.11 ± 6.77 mm.

Gupta et al.[48] (2012) studied 150 cadavers and observed that length of cystic duct was 3-4 cm.

5. Variations in the ductal system:

In the present study accessory cystic ducts were found in 2 (10%) out of 20 specimens.

Shih YJ et al.[45] reported a case of a man with a double cystic duct that was detected during elective laparoscopic cholecystectomy.

Senapati A et al.[20] reported two patients with double cystic duct. Gallbladder was normal in both the cases. The accessory cystic duct was draining into the right hepatic duct.

6. Variation in arteries related to extra hepatic biliary system:-

A] Right hepatic artery origin-

In the present study right hepatic artery was arising from hepatic artery proper in 70% specimens (most common), from common hepatic artery in 20% specimens and least commonly from superior mesenteric artery in 10% specimens.

Flint ER[2] in his study found origin of right hepatic artery from hepatic artery proper in 79% cases and from superior mesenteric artery in 21% cases. The present study is consistent with this study as author also found right hepatic artery was arising from hepatic artery proper most commonly and least commonly from superior mesenteric artery.

Hiatt et al.[21] observed that right hepatic artery was arising from hepatic artery proper in 75.7% cases (most common) and replaced or accessory right hepatic artery originated from the superior mesenteric artery in 10.6% cases (least common). The present study is consistent with them.

Futara G et al.[26] (2001) observed that the right hepatic artery took origin from the proper hepatic artery in 66.3% cases (most common), the common hepatic artery in 18.2% cases, the superior mesenteric artery in 8.2% cases or the coeliac trunk in 7.3% cases. The present study is partly consistent with them.

Jones et al.[25] (2001) observed that the right hepatic artery took origin from the main trunk of the common hepatic artery in 75% cases, arose from the superior mesenteric artery in 18%, the gastroduodenal in 6% of cases, and right gastric artery or aorta in 3 instances. The present study is not consistent with them.

Bhardwaj N[42] carried out a study over 60 cadaver and observed that RHA took origin from proper hepatic artery in 65% cases, the CHA in 20% cases, the SMA in 8.3% cases or celiac trunk in 6.6% cases.

B] Cystic artery origin-

In the present study cystic artery had origin from right hepatic artery in 85% specimens (most common) and least commonly from aberrant right hepatic artery in 15% specimens.

Flint ER[2] (1922-23) in his study observed that the cystic artery was originating from right hepatic artery in 98% cases (most common), the left hepatic artery in 1.5% cases and gastroduodenal artery in 0.5% cases. The present study is partly consistent with him.

Michels NA[17] (1951) observed that cystic artery arising from RHA in 70% cases and in 5% cases were arising from left hepatic, hepatic artery proper, retroduodenal or gastroduodenal arteries. The present study is partly consistent with him.

Similar pattern of origin were observed by Futara G et al.[26], Borley NR[6], Bakheit MA[37], Oddsdottir M et al.[41], Bhardwaj N[42], Pushpalatha et al.[44]**,** Gupta et al.[48]**,** also in their study. They also found cystic artery arising from RHA most commonly.

C] Origin of accessory right hepatic artery and accessory cystic artery-

In the present study accessory right hepatic artery was observed in 3 specimens out of 20 (15%) and had origin from hepatic artery proper (1specimen), common hepatic artery (1specimen) and from superior mesenteric artery (1specimen). Accessory cystic artery was observed in 4 specimens (20%) and had origin from accessory right hepatic artery in 2 specimens, from posterior superior pancreaticoduodenal artery in 1 specimen and from middle hepatic artery in 1 specimen.

Flint ER[2] (1922-23) found accessory right hepatic arteries in 9 (4.5%) cases which were arising from superior mesenteric artery in 7 cases and from hepatic artery proper in 2 cases. He also noted the accessory cystic artery in 31 (15.5%) cases, out of which it arose from right hepatic artery in 16 cases, from left hepatic artery in 3 cases, from gastroduodenal artery in 11 cases and from superior pancreaticoduodenal artery in 1 case. The present study is partly consistent with him.

Michels NA[17] observed accessory cystic artery in 25% cases.

Futara G et al.[26] (2001) observed 10 cases (9%)of accessory right hepatic artery which were originating from the superior mesenteric artery in 7 cases, gastroduodenal artery in 2 cases or the left hepatic artery in 1 case. There were 11 (10%) accessory cystic arteries which took origin from the right hepatic in 6 cases, the middle hepatic in 3 cases or the left hepatic arteries in 2 cases. The present study is not consistent with them.

Covey et al.[27] observed accessory RHA in 15 (2.5%) patients out of which 11 accessory RHA originated from the SMA, and one each originated from the GDA, LGA, celiac axis, and right phrenic artery. The present study is not consistent with them.

Khan et al.[3] (2008) studied 100 patients and observed accessory cystic artery in 6% cases. The present study is not consistent with them.

Bhardwaj N[42] observed 3 (5%) cases of accessory RHA which originated from SMA in 1 case and GDA in 2 cases. The author also observed accessory cystic artery in 6 (10%) cases which were arising from the RHA in 3cases, the middle HA in 2 cases or the LHA in 1 case.

D] Relation of Right hepatic artery to common hepatic duct

In the present study right hepatic artery crossed common hepatic duct posteriorly in 80% specimens, crossed common hepatic duct anteriorly in 10% specimens and did not crossed common hepatic duct in 10% specimens.

Flint ER[2] in his study observed that the RHA was crossing CHD from behind in 68% cases and from front in 12.5% cases.

Michels NA[17] observed that in 88% of cases right hepatic artery crosses posterior to common hepatic duct and in 12% of cases it crosses anterior to common hepatic duct. The present study is consistent with him.

Toufeeq AK[18] observed that the right hepatic artery was passing in front of common hepatic duct in 16% cases.

Decker GAG[22], Moore KL[7], Oddsdottir M et al.[41] had mentioned that usually RHA crosses CHD from behind. The present study is consistent with them.

E] Relation of Cystic artery to common hepatic duct

In the present study cystic artery crossed common hepatic duct posteriorly in 75% specimens (most common) and crossed common hepatic duct anteriorly in 25% specimens (least common).

Eisendrath[13] in his study had found that the CA crossed anterior to CHD in 27% cases, and in 73% cases the CA crossed posterior to CHD. Present study is similar to this study.

Flint ER[2] in his study found that CA crossed in front of the CHD in 16% cases and crossed behind it in 84% cases. Present study is similar to this study.

Saidi H et al.[50] in his study found that CA crossed CHD anteriorly in 45.1% cases and posteriorly in 46.1% cases. The other cystic arteries passed anterior to CBD in 2.9% cases, posterior to CBD in 3.9% cases, or were given off in Calot's triangle.

7. CALOT'S TRIANGLE:

In the present study boundaries of Calot's triangle were normal in all the 20 specimens. Content of Calot's triangle was normal in 13 out of 20 specimens (65%) and variations were observed in 35% specimens.

Ding et al.[4] (2007) in their study found variations in Calot's triangle in 20-50% of the patients. The present study is consistent with them.

CONCLUSION

A comprehensive study of variations of extrahepatic biliary apparatus was carried out in the Department of Anatomy, BLDEU's Shri B. M. Patil medical college, Bijapur on 20 specimens of human extra hepatic biliary apparatus by dissection method. The present study shows some differences with respect to the results from the available literature.

The gall bladder was normal in shape in 19 specimens. Hartman's pouch was seen in 1 specimen (5%). The length of GB varied from 4 cm to 9.5 cm and the average length was 6.68±1.44 cm. The width of GB varied from 2 cm to 4 cm and the average width was 2.89±0.68 cm.

Type of termination of cystic duct was angular in 95% specimens, parallel in 5% specimens and spiral type was not observed. Normal level of union of cystic duct with common hepatic duct was most commonly observed in 65%, high level of union was seen in 20% specimens and low level of union was seen in 15% specimens.

Length of CD varied from 1.2 cm to 3.5 cm and the average length was 2.26±0.59 cm. The length of CHD varied from 1.5 cm to 5 cm and the average length was 2.89±1.03 cm. The length of CBD varied from 3 cm to 8 cm and the average length was 5.7±1.23 cm.

Accessory cystic ducts were found in 10% of specimens.

RHA was arising from hepatic artery proper in 70% specimens (most common), from CHA in 20% specimens and least commonly from SMA in 10% specimens.

Cystic artery had origin from right hepatic artery in 85% specimens (most common) and least commonly from aberrant right hepatic artery in 15% specimens.

Accessory right hepatic artery was observed in 15% specimens. Accessory right hepatic artery had origin from hepatic artery proper, common hepatic artery and from superior mesenteric artery each in 1specimen. Accessory cystic artery was observed in 20% specimens. Accessory cystic artery had origin from accessory right hepatic artery in 2 specimens, from posterior superior pancreaticoduodenal artery in 1 specimen and from middle hepatic artery in 1 specimen.

Right hepatic artery crossed common hepatic duct posteriorly in 80% specimens, crossed common hepatic duct anteriorly in 10% specimens and did not crossed common hepatic duct in 10% specimens. Cystic artery crossed common hepatic duct posteriorly in 75% specimens and crossed common hepatic duct anteriorly in 25% specimens.

Thus arterial variations were more common as compared to ductal variations.

SUMMARY

The present study was intended to go through the normal anatomy and variations of extrahepatic biliary apparatus. The material of the study consisted of 20 specimens of extrahepatic biliary apparatus obtained from department of Anatomy and were studied by dissection method.

The following significant observations have been made in the present study:

1. The gall bladder was normal in shape in 95% specimens and Hartman's pouch was seen in 5% specimens only.
2. Most common type of termination of cystic duct was angular type. Normal level of union of cystic duct with common hepatic duct was most commonly observed.
3. RHA was arising from hepatic artery proper in 70% specimens (most common).
4. Cystic artery had origin from right hepatic artery in 85% specimens (most common).
5. Accessory right hepatic artery was observed in 15% specimens. Accessory cystic artery was observed in 20% specimens. Accessory cystic ducts were found in 10% of specimens. Thus arterial variations were more common as compared to ductal variations.

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PROFORMA

GALL BLADER

A) NUMBER
   1) Single
   2) Duplicated
   3) Absent

B) POSITION
   1) Extrahepatic in the fossa for gall bladder in the right lobe of liver
   2) Intrahepatic
   3) Left lobe of liver
   4) Other

C) PERITONEAL RELATIONS
   1) Inferior surface covered with peritoneum
   2) Suspended by a mesentery and covered by peritoneum

D) SHAPE
   1) pear shape
   2) Presence of Phrygian pouch
   3) Presence of bilobed gall bladder
   4) Presence of Hartman's pouch

E) DIMENSIONS OF GALL BLADDER
   1) Length
   2) Breadth

F) POSITION OF FUNDUS FROM INFERIOR BORDER OF LIVER
   1) Below the inferior border
   2) Above the inferior border
   3) At the level of inferior border

CYCTIC DUCT

A) NUMBER
   1) Single
   2) Multiple
   3) Absent

B) LENGTH

C) TYPE OF TERMINATION OF CYSTIC DUCT
   1) Angular type
   2) Parallel type
   3) Spiral type

D) LEVEL OF TERMINATION OF CYSTIC DUCT
   1) High level of union
   2) Normal level of union
   3) Low level of union

COMMON HEPATIC DUCT

A) NUMBER
    1) Single
    2) Double
    3) Absent
B) LENGTH
C) FORMATION OF COMMON HEPATIC DUCT
    1) By extrahepatic union of right and left hepatic ducts
    2) By intrahepatic union of right and left hepatic ducts

COMMON BILE DUCT

A) NUMBER
    1) Single
    2) Double
    3) Absent
B) LENGTH

VARIATION IN THE DUCTAL SYSTEM

A) Presence of accessory hepatic duct
B) Presence of accessory cystic duct

RIGHT HEPATIC ARTERY

A) NUMBER
B) ORIGIN
C) RELATION TO COMMON HEPATIC DUCT
    1) Crossing common hepatic duct anteriorly
    2) Crossing common hepatic duct posteriorly

CYSTIC ARTERY

A) NUMBER
B) ORIGIN
C) RELATION TO COMMON HEPATIC DUCT
    1) Crossing common hepatic duct anteriorly
    2) Crossing common hepatic duct posteriorly

CALOT'S TRIANGLE

A) BOUNDARIES
B) CONTENT

KEY TO MASTER CHART

N = Normal

P = Present

A = Absent

PA = Parallel

I.H. = Intrahepatic

E.H. = Extrahepatic

H = High

L = Low

AA = Above

BB = At the level

CC = Below

HP = Hartman's pouch

Acc. RHA = Accessory right hepatic artery

Acc. CA = Accessory cystic artery

Acc. CD = Accessory cystic duct

CA = Cystic artery

CHA = Common hepatic artery

SMA = Superior mesenteric artery

PSA = Posterior superior pancreaticoduodenal artery

MHA = Middle hepatic artery

RHA = Right hepatic artery

Ethical Committee
BIJAPUR-586103
OUT WARD
No 277/2011
Date 21-10-11
Shri B. M. PATIL Medical College

B.L.D.E. UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103

INSTITUTIONAL ETHICAL COMMITTEE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 20-10-2011 *at* 10-30 am *to scrutinize the Synopsis/Research projects of postgraduate/undergraduate student/Faculty members of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis/Research project has been accorded Ethical Clearance.*

Title "Study of Variations of extra hepatic Biliary apparatus in cadavers"

—x—x—x—

Name of P.G./U.G. student/Faculty member Dr. Prerna Gupta
Dept Of Anatomy

Name of Guide/Co-investigator Dr. B.B. Patil, Prof Anatomy

DR.M.S.BIRADAR,
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Chairman
Ethical Committee
BLDEA'S Shri. B.M. Patil
Medical College
Bijapur-586103

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project.
2) Copy of informed consent form
3) Any other relevant documents.

Specimen No.	Gallbladder Status (P/A)	Gallbladder Position (N/O)	Gallbladder Mesentry (P/A)	Gallbladder Shape (N/O)	Fundus (N/O)	Fundus distance from inferior border of liver (AA,BB,CC)	Neck (N/O)	Length (in cms)	Max width (in cms)	Cystic duct number	Cystic duct length (cms)	Cystic duct mode of termination (N/O)	Cystic duct level of termination (N/O)	Common hepatic duct Number	Common hepatic duct Length (cms)	Formation of common hepatic duct (E.H./I.H.)	Accessory right hepatic duct (P/A)	Accessory cystic duct (P/A)	Contents of Calot's triangle (N/O)	Common bile duct number	Common bile duct length (cms)	Right hepatic artery number	Right hepatic artery origin (N/O)	Cystic artery number	Cystic artery origin (N/O)
1	P	N	A	N	N	CC	N	7.5	3.5	1	2	N	H	1	1.5	E.H.	A	A	N	1	6	1	N	1	N
2	P	N	A	N	N	BB	N	7	2	1	2.5	N	H	1	1.5	I.H.	A	A	N+Acc. RHA	1	5.5	2	CHA	2	CA-RHA, Acc. CA-Acc. RHA
3	P	N	A	N	N	CC	N	9	3	1	3	N	N	1	2.5	E.H.	A	A	N+Acc. CA	1	5	1	CHA	2	CA-RHA, Acc. CA-PSA
4	P	N	A	N	N	AA	N	7	4	1	2.5	N	L	1	5	E.H.	A	A	N	1	3	1	N	1	N
5	P	N	A	N	N	CC	N	9	4	1	2	N	N	1	2	I.H.	A	A	N	1	4	1	N	1	N
6	P	N	A	N	N	AA	N	6	2	1	1.5	PA	N	1	2.5	I.H.	A	A	N	1	5.5	1	N	1	N
7	P	N	A	N	N	CC	N	6.5	3.4	1	1.2	N	H	1	1.8	E.H.	A	A	N	1	6.5	1	SMA	1	N
8	P	N	A	N	N	AA	N	5.5	2	1	2	N	N	1	3	I.H.	A	A	N	1	6.5	1	N	1	N
9	P	N	A	N	N	BB	N	5	2.5	1	1.5	N	N	1	2.5	I.H.	A	A	N	1	6	1	N	1	N
10	P	N	A	N	N	AA	N	4	2.5	1	3	N	N	1	2.5	E.H.	A	A	N+ Acc. RHA	1	6	2	N	1	Acc. RHA
11	P	N	A	N	N	AA	N	6	2	1	3.5	N	L	1	4	E.H.	A	A	N	1	4.5	1	CHA	1	N
12	P	N	A	N	N	CC	N	9.5	3	1	2	N	N	1	3	E.H.	A	A	N+ Acc. CA	1	6	1	N	2	CA-RHA, Acc. CA-MHA
13	P	N	A	N	N	BB	N	6	2.5	1	2.5	N	N	1	3	E.H.	A	A	N	1	5	1	N	1	N
14	P	N	A	N	N	CC	N	6.5	3.5	1	2.5	N	N	1	4	E.H.	A	A	N	1	8	1	N	1	N
15	P	N	A	N	N	AA	N	6	3	1	3	N	L	1	5	I.H.	A	P	N+ Acc. CD	1	3.5	1	N	1	N
16	P	N	A	N	N	CC	N	6.5	2.5	1	1.5	N	H	1	1.5	E.H.	A	P	N+Acc. CD	1	7	1	SMA	1	N
17	P	N	A	N	N	CC	N	7	4	1	2.5	N	N	1	3	I.H.	A	A	N	1	6.5	1	N	1	N
18	P	N	A	N	N	AA	N	4.5	3	1	2	N	N	1	3	I.H.	A	A	N	1	6.5	1	N	1	N
19	P	N	A	HP	N	CC	HP	8	2.5	1	2	N	N	1	3	E.H.	A	A	N	1	6	1	CHA	1	N
20	P	N	A	N	N	CC	N	7	3	1	2.5	N	N	1	3.5	E.H.	A	A	CA,Acc. CA, Acc. RHA	1	7	2	RHA-N, Acc. RHA-SMA	2	CA-RHA, Acc. CA-Acc. RHA