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Anatomy Section

A Study of Confluence Pattern of Hepatic Ducts at Porta Hepatis and its Clinical Significance

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ABSTRACT

Introduction: The anatomy of the area surrounding the porta hepatis is fraught with variations which often do have a strong embryological basis. Usually the right and the left hepatic duct meet at the porta hepatis to form the common hepatic duct, however considerable difference exists with respect to the number of ducts forming the confluence and the site of the same.

Aim: To examine the confluence pattern of the hepatic ducts at the porta hepatis and site of confluence of the ducts emerging from the liver to form the common hepatic duct. Presence of accessory/ aberrant ducts in the vicinity was also looked into.

Materials and Methods: This study was carried out on one hundred liver specimens with intact extra hepatic biliary ductal system in the Department of Anatomy, Jawaharlal Nehru Medical College, Sawangi (Meghe), Wardha, and Department of Anatomy, Subharti Medical College, Meerut between the period of 2008 to 2013.

Results: In 85 (85%) the usual mode of confluence i.e., the right hepatic duct and left hepatic duct joining to form the common hepatic duct was found. In 14 specimens (14%), the confluence was formed by three ducts and in one (1%), specimen by the union of four hepatic ducts. In one (1%) specimen though the confluence was formed by the right and left hepatic ducts, several small intrahepatic ducts emerged outside the liver to join the left hepatic duct. In 95(95%) specimens, the formation of common hepatic duct was extrahepatic and in five (5%) specimens it was intrahepatic. Six accessory ducts were also found in the study.

Conclusion: Substantial variations were found in our study in the mode of confluence formation and site of confluence as well as presence of accessory ducts, the knowledge of which is of paramount importance for the surgeons in successful management of diverse invasive procedures, undertaken in this region.

Keywords: Accessory, Anatomy, Hilar, Tetrafurcation

INTRODUCTION

The anatomy of the extra hepatic biliary apparatus is unique in its variability. The normal anatomy is encountered in about 50% of the population [1] and is said to have more variations in one cubic centimeter of the space around the vicinity of cystic duct than any other part of the body [2]. The variations may arise from the gallbladder or the ductal system and are often a consequence of aberration or arrest in normal developmental process in the embryonic life.

At the porta hepatis, the right and left hepatic ducts join at a variable distance below the liver to form the common hepatic duct which is then joined by the cystic duct to form common bile duct. The hepatic artery lies to the left of the common hepatic duct and the portal vein is posterior to it. The hilar area is one of the most frequented sites by the surgeons, not only because of the innumerable cholecystectomies performed, but also due to recent surge in the number of hepatic resections and liver transplantations. Surgical resection of liver is the only potentially curative therapeutic option in cases of cholangiocarciniomas involving the confluence of the right and left hepatic ducts [3]. In this study, an attempt was made to study the configuration of the hepatic ducts at the porta hepatis in terms of number of ducts forming the confluence and thereby the common hepatic duct and site of confluence formed by these ducts. Presence of accessory/ aberrant ducts emerging out of the liver and joining the common hepatic duct below the level of confluence was also looked into.

MATERIALS AND METHODS

This prospective, observational study was carried out on 100 liver specimens with intact extra hepatobiliary ductal system obtained from formalin fixed cadavers during routine undergraduate dissection, in the Department of Anatomy,

Jawaharlal Nehru Medical College, Sawangi (Meghe), Wardha, and Department of Anatomy, Subharti Medical College, Meerut, India, for the duration of five year period i.e. 2008-2013. The age of the cadavers was between 40-75 years. Out of the hundred, 90 were male cadavers and 10 were female. Cadavers with history of abdominal surgery and crush injury to abdomen were excluded from study. The study was commenced after obtaining the necessary permission from the Institutional Ethical Committee. The liver specimens were taken out from the cadavers with the pancreas and the duodenum en-masse and fine dissection was done to expose the area around porta hepatis. Magnifying lens was used to visualize the anatomy in detail. The liver parenchyma at the hepatic hilum was dissected to view the confluence whenever needed. Measurements were taken using measuring tape and calipers. Photographs were taken wherever necessary.

RESULTS

1) Configuration of the Ducts in Terms of Number of Ducts Forming the Confluence.

a. In 85 (85%) specimens out of one hundred specimens, the right and left hepatic duct joined to form the common hepatic duct [Table/Fig-1]. Out of these, in two specimens (2%) the terminal portions of the intrahepatic bile ducts forming the right hepatic duct were extra hepatic [Table/Fig-1] six small intrahepatic ducts emerged outside the liver to join the left hepatic duct. The left hepatic duct was much longer and wider i.e. 4.5cm in length [Table/Fig-2] with intraluminal diameter of 1cm whereas the right hepatic duct was very short i.e. 0.4cm in length and narrow and it appeared to be draining into the left hepatic duct which continued then as common hepatic duct.

b. In 14 specimens (14%), the confluence was formed by three ducts [Table/Fig-3].

c. In one specimen (1%), the confluence was formed by the union of four hepatic ducts [Table/Fig-4].

2) Site of Confluence

a. In 95 (95%) specimens, the formation of common hepatic duct was extra-hepatic. These included 94 (94%) specimens where the ducts forming the confluence were also extra hepatic and one specimen (1%) where the confluence was extrahepatic but the ducts forming the confluence were intrahepatic. The three ostia of the ducts opening into the common hepatic duct were only extrahepatic [Table/Fig-5].

2. In five (5%) specimens the confluence was intrahepatic and within 1cm of porta hepatis. Bits of liver tissue had to be removed to expose the confluence [Table/Fig-6]. Out of these, in 2 triple confluences pattern was seen and in the other three, the confluence was formed by two hepatic ducts.

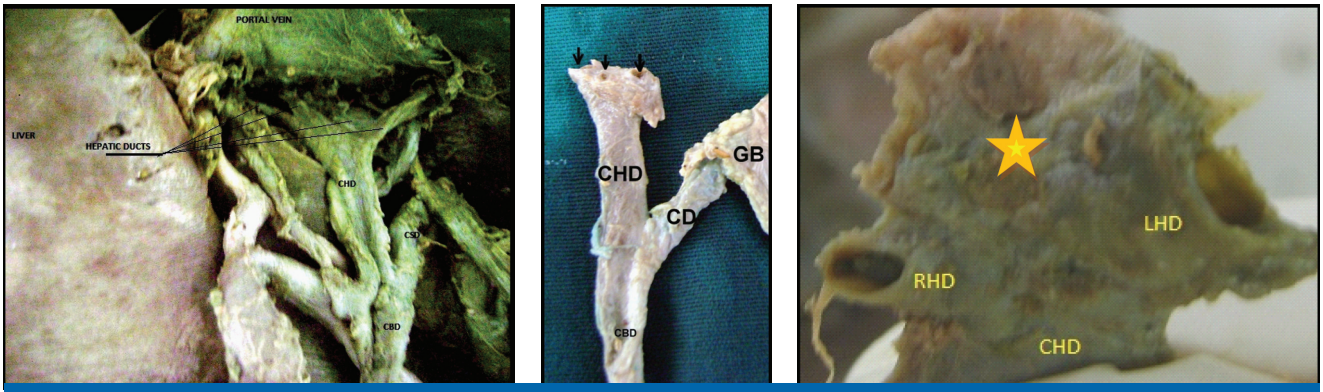
3) Accessory Ducts

In six specimens (6%), an accessory hepatic duct from the right side of the liver [Table/Fig-7]. opened into the common hepatic duct just below the level of confluence. The length of the ducts measured between three to six cm and the intraluminal diameter between 0.2 to 0.5cm and all of them were found on the right side.

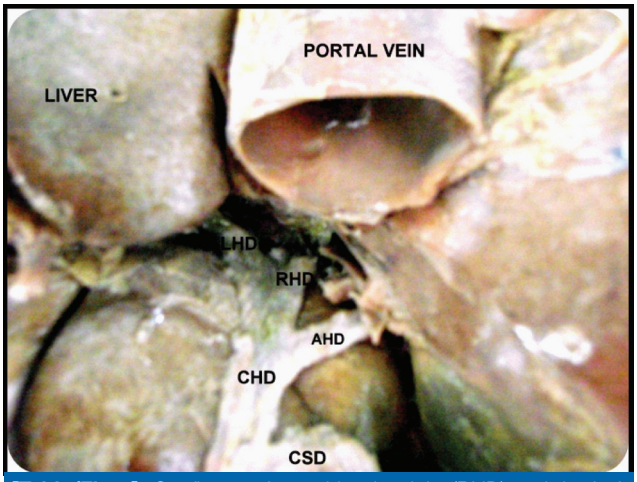
DISCUSSION

Congenital anomalies of the extra-hepatic biliary tree are frequently encountered in surgery. Their overall incidence is said to vary between 0.47% to 58% of general population [4]. They often do present as a surprise to the unaware surgeon

[Table/Fig-1]: Shows usual pattern of confluence formed by the Left hepatic duct (LHD) & Right hepatic duct (RHD) (CHD- Common hepatic duct, CSD- Cystic duct, CBD- Common bile duct).
[Table/Fig-2]: Shows several small intrahepatic ducts (1,2,3,4,5,6) draining into the left hepatic duct. (LHD- Left hepatic duct, RHD-Right hepatic duct, CHD- Common hepatic duct, CSD- Cystic duct).
[Table/Fig-3]: Shows the confluence formed by three ducts also called triple confluence. (CHD- Common hepatic duct, CSD- Cystic duct, CBD- Common hepatic duct).



[Table/Fig-4]: Shows confluence formed by four hepatic ducts. (CHD- Common hepatic duct, CSD- Cystic duct, CBD- Common hepatic duct). **[Table/Fig-5]:** In this case only the ostia of the hepatic ducts forming the confluence were extrahepatic whereas the ducts forming it were intrahepatic. **[Table/Fig-6]:** In this case confluence was formed by the right and the left hepatic ducts and the site of confluence was intrahepatic marked by a star. Bits of tissue had to be removed to expose the confluence (RHD-Right hepatic duct, LHD- Left hepatic duct , CHD- Common hepatic duct,* intra hepatic tissue)



[Table/Fig-7]: Confluence formed by the right (RHD) and the Left hepatic duct (LHD). An accessory duct (AHD) joined the common hepatic duct below it.

and hence, the knowledge of the normal and aberrant anatomy is of paramount importance, be it, the complex procedures such as living donor liver transplantations or the routine cholecystectomies.

At about the beginning of the fourth week of embryonic life the liver, gall bladder along with the biliary tree develop from an endodermal bud also called the hepatic diverticulum from the foregut. The rapidly proliferating cells of the diverticulum rapidly invaginates the septum transversum. The cranial part of the diverticulum also called pars hepatica gives rise to the liver and bile ducts, while the caudal one i.e. pars cystica to the gall bladder and the cystic duct. The stalk between the hepatic diverticulum and the foregut becomes the bile duct; its Y-shaped bifurcation becoming right and left hepatic duct. These hepatic ducts divide and re-divide subsequently to form interlobular and intralobular bile ducts. Though, earlier it was believed that the biliary tree undergoes through a phase of obliteration of its lumen by proliferating cells followed by subsequent recanalization, latest studies [5] have revealed that the lumen never obliterates and is patent from the onset of development. The entire development is guided by several cell signaling pathways such as Notch, sonic hedgehog ,Wnt and transforming growth factor 3 [6]. Kupffer cells, haemopoietic cells and connective tissue cells are derived from the mesoderm of septum transversum. Bile begins to flow at about the 12th week of intra-uterine life.

The formation of the common hepatic duct is highly variable. The most commonly encountered confluence pattern is where Right hepatic duct (RHD) and Left hepatic duct (LHD) merge to form the Common hepatic duct (CHD). The cystic duct then joins the CHD below the confluence of the RHD and LHD. This classical configuration is present in around 58- 60% of the population [7,8]. In the present study the usual configuration of the RHD and LHD forming the CHD was found in 85 % of cases. Triple confluence was found in 14%of specimens compared to 10% & 11% as observed by Choi et al., [9] & Mortele et al., [8] respectively. It has been also reported by other workers [4,9-24] mostly by imaging techniques. Tetrafurcation i.e. confluence formed by four ducts, was seen in one specimen only in this study. A case similar to this has been reported in recent literature [13]. Comparison of the data with respect to confluence pattern is tabulated in [Table/Fig-8]. El-Gharbawy et al.,[25] has reported the formation CHD by the confluence of five tributaries in a liver specimen recently.

The basis of these variations lies in appreciating the segmental anatomy of liver. The Couinaud's classification divides the liver into eight functional segments, numbered from I-VIII. The hepatic ducts follow a modal arrangement similar to that of the portal vein [20]. The CHD is formed from the reunion of the LHD supplying segments I to IV and the RHD supplying segments V to VIII. The segmental duct of segment III at first

receives the duct of segment II and IV followed by that of segment I. on the left side. The duct of segment I, might drain into the RHD [20]. This is the usual mode of confluence for LHD and is seen in 82% of population [20]. The RHD is formed from the merger of the lateral hepatic duct of segments VI and VII and the paramedian hepatic duct of segments V and VIII.

Consequently, there are many anatomic variants of the convergence of biliary ducts. Triple confluence is said to arise by simultaneous emptying of the right posterior duct (RPD), right anterior duct (RAD), and LHD into the CHD to form a trifurcation [8].

In one specimen (1%) the left hepatic duct was about 4.5cms and six small intrahepatic ducts were seen draining into it. Such as instance of smaller intra hepatic duct could not be found in the available literature however the left hepatic duct is usually longer and wider than the right hepatic duct [26].

In the present study, the formation of common hepatic duct was extrahepatic in majority (95%) of the specimens. In one specimen though the confluence was extrahepatic however the ducts forming it were intrahepatic and only the opening of the ducts were extrahepatic. In 5% of the specimens the confluence was intrahepatic and only the common hepatic duct was visible at the porta hepatis. Small portion of the liver parenchyma had to be removed to visualize the ducts forming the confluence.

Classically in 95%of cases, the site of confluence of the right and the left hepatic ducts is described to be outside the liver whereas in 5%, it is inside the liver [30] which is consistent with that found in this study. Intrahepatic confluence has been described by few authors [2,29-31]. The knowledge of site of confluence is valuable for the surgeons to ascertain length of the ductal system present both in and outside the liver, for the purposes of access and exposure. In the present study an additional single accessory /aberrant right hepatic duct was found in six specimens (6%) joining the common hepatic duct at various lengths.

Aberrant and accessory bile ducts are frequented often in this area and possess serious threat to surgeons as their inadvertent division or ligation could lead to a wide range of complications such as such as hemorrhage, leakage of bile into the peritoneal cavity, portal vein thrombosis etc., [32]. They have been reported in about 2-18% [Table/Fig-8] of cases and may arise from either the right or left intrahepatic ducts [9]. It is necessary to distinguish between the accessory

	Researcher, Year Of Study	Type of study , n= Total no of cases	Usual mode of confluence (%)	Triple confluence (%)	Tetra-furcation (%)	No. of ducts draining into CHD from Right side of liver (%)
1.	Choi et al., 2003 [9]	Choliangography, n= 300	63	10	--	6
2.	Dusunceli & Erden, 2004 [10]	MRCP, n=475	75.78	0.8	-	-
3.	Sharma et al., 2008 [11]	ERCP, n=253	52.9	11.46	-	7.1
4.	Karakas et al., 2008 [12]	MRI, n=134	61	16	-	10
5.	Kostov & Kobakov, 2011 [13]	Cholangiography, Segmentectomy, hemihepatectomy, n=758	40.5	11.8	2	3
6.	Mariolis-Sapsakos et al., 2012 [14]	Cadaveric, n=73	65.75	9.59	-	18.81
7.	Thungsuppawattanakit, 2012 [15]	MRCP, n=106	65	17.2	-	5.5
8.	Cachoeira et al., 2012 [16]	Cadaveric, n =41	95.12	2.4	-	-
9.	Tawab et al., 2012 [17]	3.0-T MR Cholangiography, n=106	63.2	10.4	-	7.5
10.	Abdelgawd & Eid , 2012 [18]	MRCP, n=20	80	5		5
11.	Barsoum, 2013 [19]	Living Donor Liver Transplantation, n=50	60	6		4
12.	Chaib et al., 2014 [20]	Retrospective study by collection of data, n= 2032	61.3	14.5		6.1
13.	Uysal et al., 2014 [21]	MRCP, n=1011	79.4	8.01		7.23
14.	Deka et al., 2014 [22]	MRCP, CT Cholangiography, n=299	57.8	8		14
15.	Al-Jiffry, 2015 [23]	Laproscopic cholecytectomy, n =177	59	10.7		18
17.	Sarawagi et al., 2016 [24]	MRCP, n= 224	55.5	9.3		4
18.	Devi & Krishna, 2013 [27]	Cadaveric, n=50	-	-	-	5
18.	Awazli, 2013 [28]	Cholecystectomy, n=150	-	-	-	2
20.	Anupama et al., 2016 [29]	Cadaveric, n=50				2
21.	Present study	Cadaveric, n=100	85	14	1	6

[Table/Fig-8]: Comparison of data of confluence of hepatic ducts at porta hepatis amongst researchers.

and aberrant types as the accessory one is an extra duct that drains the same segment of the liver whereas the aberrant one drains a particular hepatic segment [8]. Comparison of data as found by different researches is given in [Table/Fig-9]. Accessory ducts are thought to arise from an additional bud of the hepatic diverticulum during organogenesis [33] or may be a consequence of delayed division of the same [2,4]. In about 11% [16] to 25% [26] of cases where the confluence is formed by two ducts , a duct from the right side of the liver drains into common hepatic duct below the level of confluence forming the "convergence ētageē"also known as the selved confluence [26] found in two specimens in this study.

	Researcher	Year	Type of Study	Extrahepatic Confluence (No of Cases)	Intrahepatic Confluence (No of Cases)
1.	Paul et al., [30]	2013	Cadaveric	48	2
2.	Koshariya et al.,[31]	2016	Cadaveric	97	3
3.	Anupama et al.,[29]	2016	Cadaveric	23	27
4.	Present Study	2016	Cadaveric	95	5

[Table/Fig-9]: Site of confluence as found by different researchers.

As already mentioned the hepatic hilar and the peri-hilar area are fraught with variations, which can be both ductal and vascular in nature. These complications if not properly managed may be associated with mortality as high as 5% [34]. Therefore, the onus lies on the surgeon to be well acquainted with the usual and variant anatomy in order to prevent biliary injuries [35] and complications like biloma, bile peritonitis, biliary fistula, liver abscess, multiple organ dysfunction syndrome etc.,[34] . Long term sequelae and repeated attacks of cholangitis might also ensue [34].

LIMITATIONS

The main limitation of this study was that the extrahepatic ductal portion was only studied except in those cases where the confluence was intrahepatic and hence the origin of the ducts forming the triple confluence and the tetrafurcation could not be ascertained. For the same reason it was not be possible to distinguish whether the accessory ducts found in the present study were aberrant or true accessory in nature. It was also not possible to correlate the variations found with the clinical findings (if there were any), since the study was a cadaveric one.

CONCLUSION

In the present study, apart from usual pattern of ductal confluence at the at porta hepatis, triple confluence and tetrafurcation was also observed. The site of confluence was extrahepatic in majority of the cases barring five where it was intrahepatic. In addition six accessory ducts were also found. The variable ductal anatomy often gets complicated with even more variable vascular anatomy, knowledge of which is of utmost importance for the surgeons in successful management of diverse invasive procedures, undertaken in this region.

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