ORIGINAL RESEARCH

Morphometric Analysis of the Hepatic Ducts: A Study on Autopsies

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Abstract

Objective: Human biliary tract consists of right, left, common hepatic, cystic, and bile ducts. A comprehensive knowledge of these ducts' parameters will be helpful in surgical and radiological practice. This study aimed to morphometrically analyze human bile ducts in fresh autopsies.

Methods: In this descriptive study, 35 extrahepatic biliary tracts of deceased bodies, subjected to medico-legal autopsies at Department of Forensic Medicine, Faculty of Medicine, University of Peradeniya were dissected. Lengths and external diameters of right hepatic duct (RHD) left hepatic duct (LHD), and common hepatic duct (CHD) were measured using a calibrated digital vernier caliper.

Results: Thirty-five fresh liver and biliary tract samples were studied. Mean age of the deceased was 63.2 years. There were 32 Huang Type A1 and 3 Huang Type A2 bile duct variants. Mean lengths of RHD, LHD and CHD were 14.0 mm (SD–8.53, range 4.91–37.5 mm), 21.7 mm (SD–8.91, range 6.29–40.4 mm), 26.8mm (SD–11.9, range 9.7–74.9 mm) with diameters of 3.76 mm (SD–1.52, range 1.83–7.96 mm), 3.18 mm (SD–1.2, range 1.52–7.49 mm), 3.88 mm (SD–1.42, range 1.65–8.32 mm) respectively. There was a statistically significant positive correlation between diameters of RHD and CHD (Spearman's rho=0.387, p=0.029) and diameters of LHD and CHD (Spearman's rho=0.412, p=0.017). There was no significant difference between genders.

Conclusion: There are significant positive correlations between diameters of RHD & CHD and LHD & CHD with no statistically significant difference between genders. Mean RHD, LHD, and CHD values are within ranges reported in literature. In this Sri Lankan sample, Huang Type A1 was the prominent variation.

Keywords: Biliary tract, Common hepatic duct, Autopsy, Cholecystectomy, Sri Lanka

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Introduction

The human extrahepatic biliary tract consists of the right hepatic duct (RHD), left hepatic duct (LHD), common hepatic duct (CHD), common bile duct (CBD), cystic duct (CD), and the gall bladder (1, 2). The RHD and LHD exit through the hepatic hilum and join making a Y-shaped junction to become the CHD. A normal CHD is about 1–4cm long from the confluence to the level of joining of CD to the CHD, and about 4mm in diameter (1,3,4). Usually, the RHD is short, wide and lies more vertically. The LHD is long, narrow, and lies more horizontally (1,5).

This area is a common site for surgical procedures (2,6). A thorough knowledge of morphologic as well as morphometric anatomy and variations is crucial for avoiding complications during and after surgery (2,3). Especially when the lengths of CHD and CD determine the surface area of Calot's triangle, a vital anatomical landmark when performing cholecystectomy. Further, measurements of hepatic ducts are useful in management of hilar carcinoma, liver resection, transplantation, and endoscopic interventions of the liver (2,5).

This knowledge is helpful in surgical and radiological practice and only a few studies are available from Sri Lanka. We aim to analyze the external measurements of the human hepatic ducts in fresh autopsy samples.

Methods

In this descriptive study, the extrahepatic biliary tract of fresh deceased bodies, aged ≥18 years, subjected to medico-legal autopsies conducted by a Judicial Medical Officer at the Department of Forensic Medicine, Faculty of Medicine, University of Peradeniya, from June 2023 to February 2024 were included. Deceased bodies with abdominal trauma, putrefaction, liver transplant, abdominal surgical complications resulting in death, abdominal pathology, extensive adhesions within the abdominal cavity, and foreign ethnicity were excluded. An anatomist did all the dissections of the extrahepatic biliary tract. The lengths and external diameters of RHD, LHD, and CHD were measured using a calibrated digital vernier caliper (3,5,7).

For measuring hepatic duct length, the distance between the proximal end (commencement of the duct by the union of the intrahepatic ducts for RHD/LHD, the commencement of the duct by the union of hepatic ducts for CHD) and the distal end (confluence for RHD/LHD and point of joining of the CD for CHD) of the duct was measured. For the measurements of hepatic duct diameter, beginning of the duct/ proximal end was considered. Two measurements perpendicular to each other were taken in millimeters (mm) and averaged (8). The bile duct pattern was observed, documented according to the Huang classification type, and photographed.

Statistical analysis was done with the jamovi project (2022), jamovi (Version 2.3) computer software (9). Descriptive analysis with mean, range, and standard deviation was calculated. Spearman's rho test for correlation was used to describe associations between the ducts' lengths and diameters. The Mann-Whitney U test was used to check whether there was a difference between genders. A *p-value* <0.05 was considered statistically significant.

Results

The specimens consisted of 35 fresh liver and biliary tract samples (21 male - 60%) with a mean age of 63.2 years (standard deviation [SD] – 15.9, range 23 – 88 years). The majority belong to the Sinhalese ethnicity (88.5%) and the rest were from the Tamil ethnic group. A summary of demographic data is shown in Table 1 and Figure 1.

The hepatic duct variations (Huang Types) were also studied (10,11). Among the 35 samples, 32 were Huang Type A1 while the other 3 were Huang Type A2. Figure 2 illustrates the Huang types of biliary ductal variations.

Table 1: The summary of demographic data

Descriptive	n	%
Sample size	35	
Male	21	60
Female	14	40
Age (Years)		
Mean	63.2	
Standard deviation (SD)	15.9	
Range	23 - 88	
Ethnicity		
Sinhalese	31	88.5
Male	18	
Female	13	
Tamil	4	11.5
Male	3	
Female	1	

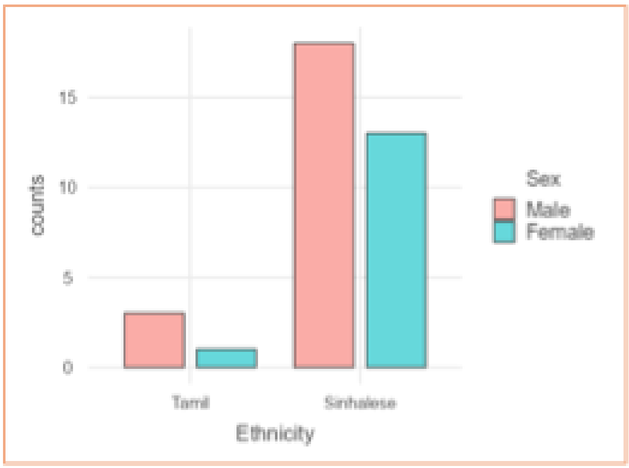

Figure 1: Demographic variation of the sample

The mean length of RHD is 14.0 mm (SD – 8.53, range 4.91 mm – 37.5 mm). The mean diameter of RHD is 3.76 mm (SD – 1.52, range 1.83 mm – 7.96 mm). The mean length of LHD is 21.7 mm (SD – 8.91, range 6.29 mm – 40.4 mm). The mean diameter of LHD is 3.18 mm (SD – 1.2, range 1.52 mm – 7.49 mm). The mean length of CHD is 26.8 mm (SD – 11.9, range 9.7 mm – 74.9 mm). The mean diameter of CHD is 3.88 mm (SD – 1.42, range 1.65 mm – 8.32 mm). A summary of the measurements is given in Table 2.

There is a significant positive correlation between the diameters of RHD & CHD (Spearman's rho = 0.387, p = 0.029) and the diameters of LHD & CHD (Spearman's rho = 0.412, p = 0.017) suggesting that as the diameter of the RHD and/ or LHD increases, the diameter of the CHD also tends to increase, and this relationship is statistically significant.

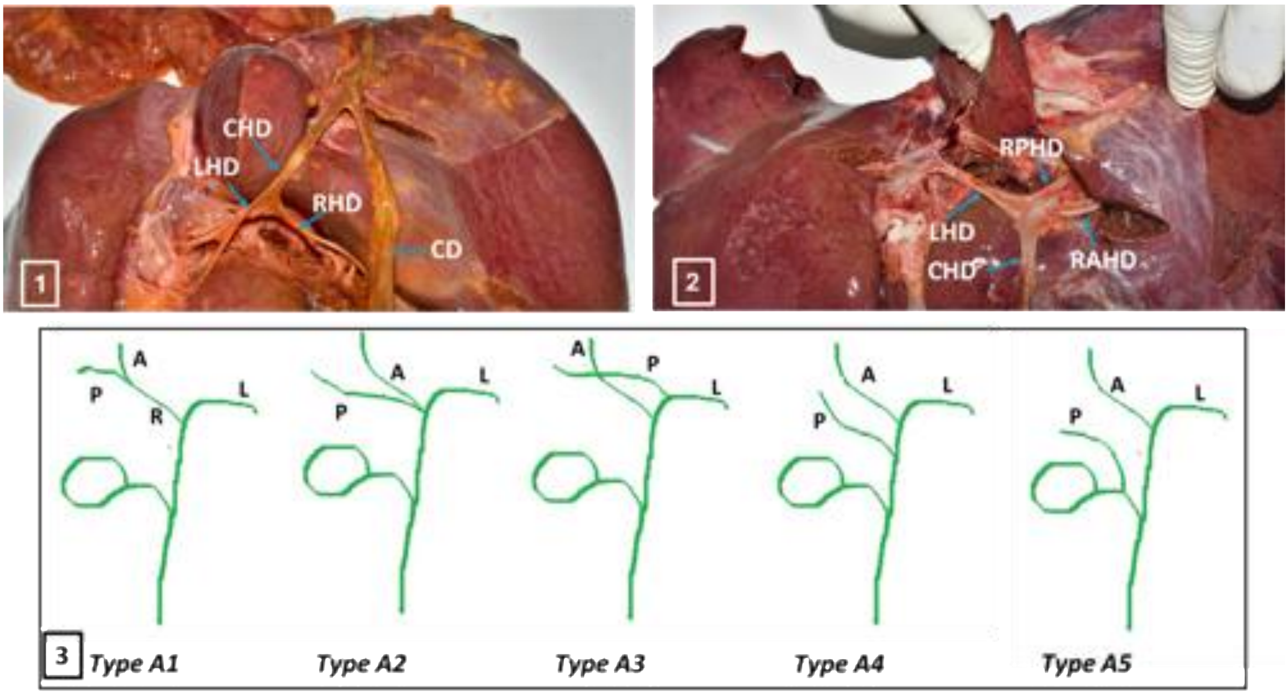

Figure 2: 1 - Biliary system with Huang Type A1, 2 - Biliary system with Huang Type A2, 3 - Huang classification of biliary ductal variations. (RHD – right hepatic duct, LHD – left hepatic duct, CHD – common hepatic duct, CD – cystic duct, RAHD – right anterior hepatic duct, RPHD – right posterior hepatic duct, A – right anterior duct, P – right posterior duct, R – right hepatic duct, L – left hepatic duct)

Table 2: The summary of the measurements

Descriptives	Lengths (mm)			Diameters (mm)		
	L-RHD	L-LHD	L-CHD	D-RHD	D-LHD	D-CHD
N	32	34	35	32	33	35
Missing	3	1	0	3	2	0
Mean	14.0	21.7	26.8	3.76	3.18	3.88
SD	8.53	8.91	11.9	1.52	1.20	1.42
Range	32.6	34.1	65.2	6.13	5.97	6.67
Minimum	4.91	6.29	9.70	1.83	1.52	1.65
Maximum	37.5	40.4	74.9	7.96	7.49	8.32

(L-RHD – length of RHD, D-RHD – diameter of RHD, L-LHD – length of LHD, D-LHD – diameter of LHD, L-CHD – length of CHD, D-CHD – diameter of CHD, N – number, SD - Standard deviation)

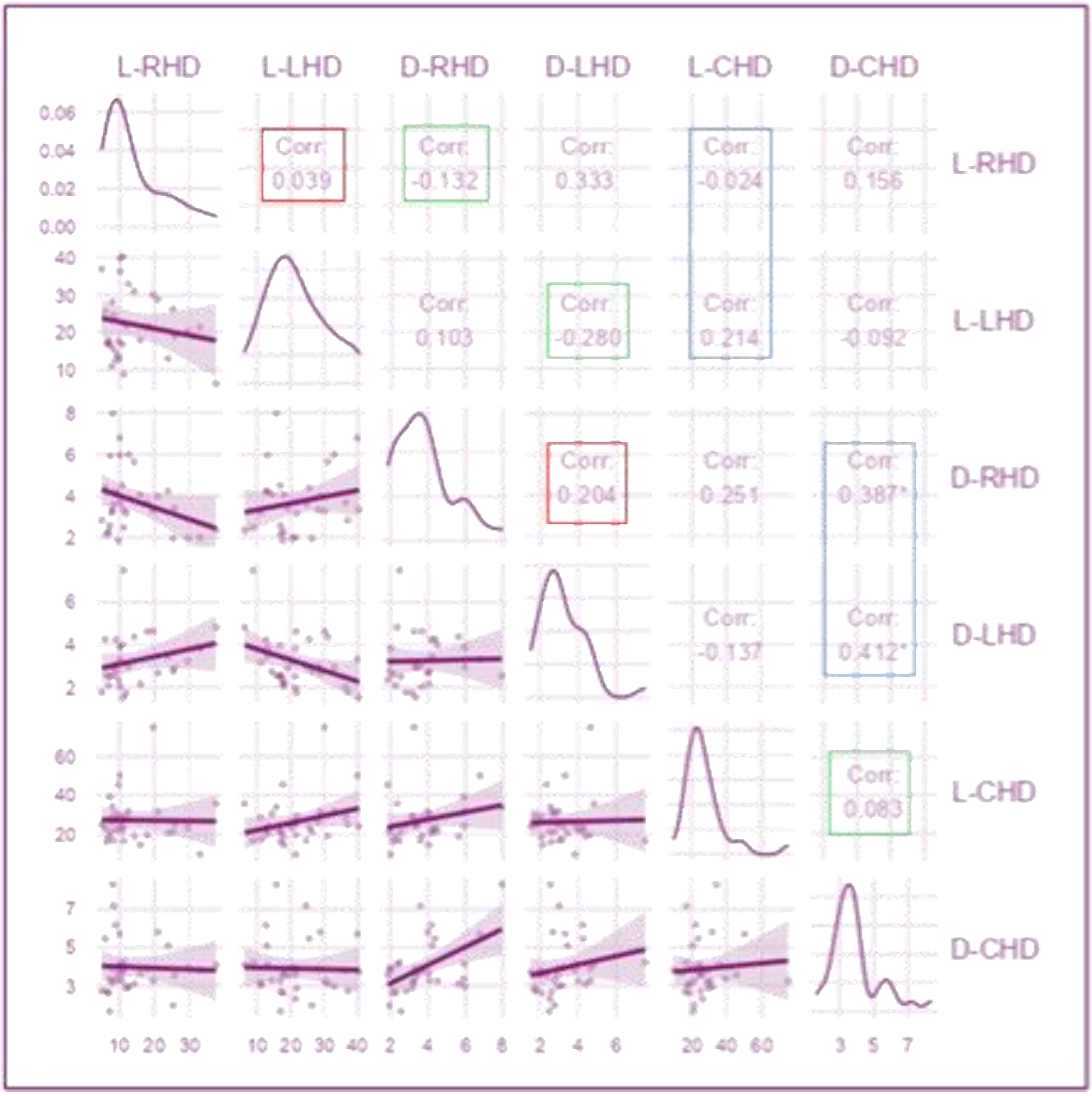

Figure 3: Correlation matrix with statistics and densities for variables (D-RHD – RHD diameter, D-LHD – LHD diameter, D-CHD – CHD diameter, L-RHD – RHD length, L-LHD – LHD length, L-CHD – CHD length)**.** (Red boxes – correlations between variables of RHD and LHD, Green boxes - correlations between variables of the same duct, Blue boxes - correlations between variables of RHD and LHD with variables of CHD).

The other pairs of variables show weak or negligible relationships that are not statistically significant (p-values > 0.05), indicating that those pairs do not have strong associations.

A summary of the associations between the variables is shown in Table 3 and Figure 3.

Table 3: The summary of the associations between the variables

Variables	Spearman rho	*p*	Correlation	Significance
L-RHD & L-LHD	0.039	0.834	Negligible	Not significant
D-RHD & D-LHD	0.204	0.277	Weak positive	Not significant
L-RHD & D-RHD	-0.132	0.471	Negligible	Not significant
L-LHD & D-LHD	-0.280	0.114	Weak negative	Not significant
L-CHD & D-CHD	0.083	0.635	Negligible	Not significant
L-RHD & L-CHD	-0.024	0.896	Negligible	Not significant
L-LHD & L-CHD	0.214	0.224	Weak positive	Not significant
D-RHD & D-CHD	0.384	**0.029**	Weak positive	**Significant**
D-LHD & D-CHD	0.412	**0.017**	Moderate positive	**Significant**

($p<0.05$ = statistically significant)

Table 4: Summary of measurement comparison between male and female genders

Descriptives	Lengths (mm)						Diameters (mm)					
	L-RHD		L-LHD		L-CHD		D-RHD		D-LHD		D-CHD	
	M	F	M	F	M	F	M	F	M	F	M	F
N	19	13	20	14	21	14	19	13	20	13	21	14
Missing	2	1	1	0	0	0	2	1	1	1	0	0
Mean	14.53	13.31	22.47	20.65	28.60	24.23	3.71	3.83	3.11	3.30	3.86	3.91
Median	10.79	10.08	21.55	17.48	25.65	21.73	3.59	3.19	2.96	2.76	3.56	3.41
SD	9.04	8.02	8.58	9.57	13.32	9.07	1.24	1.92	1.02	1.47	1.08	1.86
SE	2.073	2.225	1.919	2.558	2.907	2.424	0.285	0.533	0.227	0.408	0.236	0.497
M-W U	109		113		104		116		129		133	
M-W U (*p*)	0.596		0.359		0.148		0.791		0.986		0.637	

(M-W U- Mann-Whitney U test, $p<0.05$ = statistically significant, N – number, SD – Standard deviation, SE – Standard error, M – male, F - female)

The mean lengths of RHD, LHD, and CHD were higher in males (14.53 mm, 22.47 mm, and 28.6 mm) than in females (13.31 mm, 20.65 mm, 24.23 mm). In contrast, the mean diameters of RHD, LHD, and CHD were higher in females (3.83 mm, 3.3 mm, and 3.91 mm) than in males (3.71 mm, 3.11 mm, and 3.86 mm). However, this difference in means of ductal lengths and diameters between genders was not statistically significant. A summary of measurement comparison between genders is shown in Table 4.

Discussion

In the surgical and radiological fields, the anatomy of the biliary tract, their variations, and morphometry are important to maintain proper procedures and avoid possible complications. The present study used fresh human autopsy specimens of the biliary tract within the first 24 hours from the time of death to analyze the morphometry of the hepatic ducts. All the bile ducts evaluated appeared grossly normal.

There are several variations in the biliary tract and their drainage patterns. These patterns have been evaluated and classified by several authors and one of the most used classifications is Huang classification of biliary tract variants (10, 11). This classification has five variants that describe the inserting pattern of the right posterior hepatic duct (RPHD). Huang Type A1 is where the RHD was formed from the union of the RPHD and the right anterior hepatic duct (RAHD). Huang Type A2 is where LHD, RPHD and RAHD join in a triple confluence to form the CHD. In Huang Type A3, the RPHD drains directly into the LHD and in Huang Type A4, the RPHD drains into the CHD. Huang Type A5 is where RPHD is drained into the CD.

Here, we included the main Huang variants of the biliary tract. Among the 35 samples, 32 were of Huang Type A1. The other 3 belonged to Huang Type A2.

When comparing our findings on length and diameter, the LHD length is larger than that of RHD and the diameter of RHD is larger than that of LHD. These results are in line with previous literature on the RHD being usually short and wide while the LHD is long and narrow. The CHD has larger dimensions than both RHD and LHD.

Morphometric evaluation of hepatic ducts has been studied involving cadavers, postmortem samples, and imaging studies such as magnetic resonance cholangiopancreatography (MRCP) and endoscopic retrograde cholangiopancreatography (ERCP) in different populations (1 – 3, 5, 6, 11 - 14). A comparison between the findings of the present study and previous studies is summarized and presented in Table 5. The figures observed in the present study are within the length and diameter ranges reported in the literature (1, 3, 5, 6, 11, 12, 15).

A cadaveric study done in Sri Lanka reports similar means to our results for RHD length and CHD diameter, 13.3 mm and 3.8 mm respectively. The findings on lengths of LHD and CHD are lower than our findings and the author has not analyzed the diameter of RHD and LHD (14).

Table 5: **Comparison of present study results with previous studies**

Study	Sample type	n	Mean (mm)					
			L-RHD	L-LHD	L-CHD	D-RHD	D-LHD	D-CHD
Khatiwada et al., 2017 (5)	Cadavers	32	10.48	20.77	-	3.37	2.54	-
Santos Conceição et al., 2022 (3)	Cadavers	13	-	-	30.02	-	-	3.74
Quijano, 2020 (11)	Cadavers	60	10.64	10.74	25.595	3.62	3.636	4.975
Cachoeira et al., 2012 (2)	Cadavers	39	-	-	21.76	-	-	-
Khayat et al., 2014 (6)	ERCP & MRCP	120	17.7	28.5	21.9	-	-	-
Deka et al., 2013 (12)	MRCP	299	10.06	7.83	22.05	2.59	2.92	4.14
Kim et al., 2002 (13)	ERCP	306	-	-	-	-	-	5.3
Elena et al., 2018 (15)	Cholangiogram	16	3 - 25	4.2-24.9	20.2-52.9	4.2-7.2	3.5-6.6	3.9-9.7
Eftekhar-Vaghefi et al., 2013 (1)	Postmortem	50	17.15	14.75	19.91	8.63	6.61	9.75
Abeysuriya, 2010 (14)	Cadavers	60	13.3	13.2	24	-	-	3.8
Present study	**Postmortem**	**35**	**14.0**	**21.7**	**26.8**	**3.76**	**3.18**	**3.88**

Another postmortem study from Iran has looked into lengths and diameters of RHD, LHD, and CHD but all the mean values are higher than our results except for LHD and CHD lengths which are much lower (1). Quijano et al.'s study on 60 cadaver specimens had similar results to our findings considering the length of CHD and diameters of RHD and LHD (11).

Farias et al. have studied the distance from hilar confluence to separate left-side segmental ducts and to the ligamentum venosum in fresh frozen postmortem samples. According to them, the left lobe is more suitable for transplantation when there are right-side bile duct variations and when a single duct anastomosis can be obtained after left lobe resection. The authors have achieved this by observing the confluence of segment 2 and 3 ducts (16). In our study, we did not measure the distance of LHD from the hepatic confluence to the ligamentum venosum or to separate segmental ducts.

It should be noted that the LHD length should be at least 15 mm from the RHD-LHD confluence to avoid major segmental bile duct injury such as caudate lobe duct during left hemi hepatectomy (17). Our sample population mean well exceeds this value although the minimum value is lower than 15 mm.

Lengths of ducts directly contribute to the surface area of Calot's triangle. On the other hand, long ducts and low insertion of CD with CHD may be associated with certain pathologies such as bile stones, Mirizzi's syndrome, and pancreatitis (2).

The findings of studies using imaging modalities vary from our results. We measured the external diameter while imaging studies usually measure the internal diameter. The other difference is that while the postmortem biliary tract is in a collapsed state, in imaging studies the biliary tract is filled with either a contrast agent or bile. It is said that the measurement values can be higher in imaging studies using contrast due to the magnification of images and ductal distension from the contrast media (5).

The discrepancies between available literature can also be due to the changes in the cross-sectional shape of the ducts. It may not be circular even when it is distended. While ultrasound allows anteroposterior diameter, computed tomography or MRCP allows the measurement of the largest possible diameter (18).

A weak positive correlation was found between the diameters of RHD and CHD and a moderate positive correlation between the diameters of LHD and CHD. Both these correlations were statistically significant with a p-value of 0.029 and 0.017 respectively. Associations between all other variables were not significant. Correlations between the lengths of RHD and LHD, length and diameter of RHD, length and diameter of CHD, and lengths of RHD and CHD were negligible. Correlation between diameters of RHD and LHD, lengths of LHD and CHD are weakly positive. The correlation between the length and diameter of LHD is weakly negative. Khatiwada et al. reports a negative correlation between lengths of RHD and LHD which is different from our findings (5).

When the Mann-Whitney U test was used it was revealed that there was no significant difference in these parameters between genders. One study has found that there is a difference in the lengths of RHD, LHD and CHD between genders but has not analyzed whether it is statistically significant or not (15).

Limitations and future directions

Due to limited ethnic variation, analysis with ethnicities was not possible.

Conclusion

Significant correlations are observed only between the variables D-RHD & D-CHD and D-LHD & D-CHD. Both correlations are positive and significant, suggesting that higher values of D-RHD or D-LHD are associated with higher values of D-CHD. There is a clear difference between the mean values of males and females, but it is not statistically significant. The mean length and diameter values of RHD, LHD and CHD of this Sri Lankan population are well within the ranges reported in the literature and seem suitable for left lobe liver surgeries including transplantation.

Huang Type A1 variation is the prominent bile duct variation in this sample. It is the main and typical variant type reported in the literature (10 - 12).

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Ethical approval

Ethics Review Committee, Faculty of Medicine, University of Peradeniya (2022/EC/59).

Conflict of interest: None.

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Author contributions

MJSJ – Data acquisition, Sample dissection, drafting original manuscript, reviewing and editing the original manuscript. EMKBE – Data acquisition, Reviewing and editing the original manuscript. JU – Reviewing and editing the original manuscript. HA - Reviewing and editing the original manuscript.

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