Morphological Expression of the Extrahepatic Bile Duct. A Study in a Sample of Colombian Mestizo Population

Bladimir Saldarriaga Tellez¹,², Edgar Giovanni Corzo¹, Pedro Luis Forero²,³, Luis Ernesto Ballesteros Acuña²,¹

Abstract

Background: The great variability of the extrahepatic bile duct (EBD) has clinical-surgical implications. The objective of this study was to characterize the morphological expressions of EBD.

Methods and Findings: This descriptive study, done by injecting a semi-synthetic (Palatal GP40L 85%; styrene 15%) impregnated with mineral green dye into the gallbladder, to determine the anatomical characteristics and the biometrics of EBD in 33 blocks fixed with formaldehyde formed from the supra-mesocolic floor. The gallbladder presented a length of 66.9 ± 1.7 mm. The Hartmann’s Pouch was observed in 16 specimens (50%). The lengths of the cystic duct (CD), common hepatic duct (CHD) and common bile duct (choledoch duct) were 27.8 ± 1.6 mm, 28.6 ± 11.39 mm and 60.6 ± 11.6 mm respectively.

The presence of accessory hepatic ducts (AHD) was found in three samples (9.1%). In 29 specimens (87.9%) the cystic duct presented medium length, while in 4 cases (12.1%) the CD was long (P < 0.05). The trajectory of the lateral oblique of CD was present in 23 cases (69.7%), with statistically significant differences in relation to the other trajectories of the CD (P < 0.05). In 18 samples (55%) the cystic-hepatic union appeared at the level of the middle third of the EBD, while in 15 (45%) cases the union of the CD was low (P < 0.05).

Conclusions: The mathematical distribution of the segments of the EBD, carried out in this study, provides reliability to the assessment of the cystic-hepatic junction level. The presence of CHA and the level of the cysto-hepatic junction are important anatomical references, especially in emergency room procedures.
Introduction

The extra hepatic bile duct (EHBD) is formed at the level of the hepatic hilum, by the junction of the right and left hepatic ducts (RHD, LHD), which form the common hepatic duct (CHD). The CHD joins the cystic duct (CD) and forms the common bile duct or choledoch duct (ChD), which flows into the second portion of the duodenum [1].

The gallbladder (GB) is lodged in a pit of the visceral face of the liver, is variable in its shape and size, it is generally located between segments IV and V of the liver. It recognizes the fundus, body and neck, which may be partially or completely embedded in the liver parenchyma [2]. Agenesis of the GB is presented without atresia of the EBD, with an incidence lower than 1 in 6000 births, or GB duplicated or tripled in one of 4000 autopsies. [3] Likewise, it has been reported a very low incidence (one in 1600 Autopsies) of ectopic location of the GB at the retro renal, supra-hepatic, intrahepatic, anterior abdominal wall or at falciform ligament level [3].

At the level of the neck, the GB can present the Hartmann’s pouch (Hp), variable dilation in shape and size, which can hide or limit the visibility of the cystic duct in the hepatobiliary triangle [2]. Hp has been reported in a range of 52-74% of the cases and its presence has been associated with a higher incidence of cholelithiasis [4].

The cystic duct (CD) has a variable length of 4-35 mm [5, 6, 7, 8] and an external diameter of 3-12 mm [4]. It has been reported that the middle third of EBD is the most frequent site of hepatic cystic union, with an incidence of 16.9-54.2% [9]. One variable of the EBD to be considered is the presence of accessory hepatic ducts (AHD), which originate mainly from the right lobe, in a range of 1-30% [3, 5,10, 11]. AHD drains mainly the CHD or RHD.

A preoperative evaluation is required through the use of diagnostic imaging of the anatomic variants of the EBD, to prevent surgical complications in liver transplants. Complications of the biliary tract occur in 7-10% of donors, and represent the most common cause of morbidity in living donors of liver transplants [10]. The knowledge of how CD joins to CHD is of relevance in liver surgery for the application of a clip and for a more precise sectioning of the CD [12].

The importance of the knowledge of the morphological expression of the EBD lies, in addition to the academic concept, in its impact on programmed and emergency hepatic surgery, in the interpretation of imaging studies and in the management of clinical events in which these anatomical structures can be compromised. [10, 12, 13]. The determination of EBD morphology has been described by classical dissection techniques, injection-corrosion technique or radiographic studies, in other population groups different from the Latin American mestizo population, some with a clear basic-clinical orientation [9, 14, 15, 16]. The scarce information of this type in this population, gives relevance to the present study, developed in a sample of Colombian cadaveric material, with the purpose of obtaining its own reference information.

Methods

This non-probabilistic and descriptive cross-sectional study determined the morphological expressions of the EBD in 33 blocks fixed with formaldehyde of the supramesocolic floor of unclaimed corpses of adult male individuals who underwent an autopsy at the Institute of Legal Medicine of Bucaramanga, Colombia. Trauma or pathologies involving the liver or bile ducts were determined as exclusion criteria.

A small incision was made in the bottom of the GB and a number 14 catheter fixed with silk was installed; the biliary tract was flushed with a physiological saline solution to eliminate the bile residues and a silk repair was applied around the opening of the hepatopancreatic ampulla in the duodenal papilla. Subsequently, the bile duct was perfused through the catheter installed in the vesicle, with
semi-synthetic resin (mixture of 85% GP40L palatal with 15% styrene and green colored mineral.) The volume of resin injected was determined by the size of the gallbladder and the positive pressure offered by the plunger of the syringe to the operator, then the biliary tract structures were dissected from their origin to their distal segments. Subsequently, the external diameter and length of the structures that make up the EBD were measured with an electronic calibrator (Mitutoyo®). The dimensions of the supraduodenal, retroduodenal and intrapancreatic segments of the ChD were evaluated [17]. The presence of Hp, ABD, and trajectories of CD (lateral oblique, sinuous, medial oblique, parallel, posterior circular) was determined [3].

According to the criteria of Khayat et al 2014 [5] the size of the CD was determined as short, with length less than 10 mm, medium when its length ranged from 11-40 mm and long if it was greater than 40 mm. Likewise, the level of binding of CD to CHD was determined as high, medium or low if the cystic-hepatic junction was located in the upper, middle or lower thirds of the junction of the CHD with the supraduodenal segment of the ChD. Photographic records of each of the anatomical pieces evaluated were obtained.

In the data analysis, the continuous variables were described with their average and standard deviation, as well as the nominal variables with their proportions. The statistical tests of chi (X2) square and student test were carried out accepting an alpha error of up to 5%. The data was entered as a database in Excel and the statistical analysis was performed in STATA 12.0.

Results

In all the samples, GB was unique and no ectopic location of this structure was observed. The GB presented a length of 66.9 mm (SD 1.7). The Hartmann’s pouch was observed in 16 specimens (50%) (Table 1, Figure 1).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Length</th>
<th>Range (mm)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallbladder length</td>
<td>66.9</td>
<td>46.7-82</td>
<td>9.4</td>
</tr>
<tr>
<td>Gallbladder’s Wide bottom</td>
<td>31.4</td>
<td>24.2-47.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Gallbladder’s Body width</td>
<td>28.8</td>
<td>21.2-42.7</td>
<td>4.2</td>
</tr>
<tr>
<td>Length of the gallbladder’s neck</td>
<td>15.8</td>
<td>10.9-22.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Length of the Hartmann’s pouch</td>
<td>18.2</td>
<td>15-23</td>
<td>2.2</td>
</tr>
<tr>
<td>Width of the Hartmann’s pouch</td>
<td>9.9</td>
<td>7.6-14.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Right hepatic duct length</td>
<td>10.3</td>
<td>6.6-17.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Right hepatic duct diameter</td>
<td>4</td>
<td>2.8-5</td>
<td>0.7</td>
</tr>
<tr>
<td>Left hepatic duct length</td>
<td>12.6</td>
<td>8.2-18.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Left hepatic duct diameter</td>
<td>3.1</td>
<td>2.1-4.4</td>
<td>0.6</td>
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<tr>
<td>Cystic duct length</td>
<td>27.8</td>
<td>15.2-53</td>
<td>9.1</td>
</tr>
<tr>
<td>Cystic duct diameter</td>
<td>3.3</td>
<td>2.2-6</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The length of the RHD was 10.3 mm (SD 0.5), while the length of the CD was 27.8 mm (SD 1.6). (Table 1, Figure 2)

The lengths of the CHD and CD were 28.6 mm (SD 1.39) and Choledoch duct (ChD) 60.6 mm (SD 1.6) respectively. The supraduodenal segment of the ChD measured 15.5± 1.1 mm (Table 2, Figure 3, 4). The hepatopancreatic ampulla presented a width of 7.3 ± 0.3 mm with a range between 4.6 and 9.3 mm (SD 1.2 mm).

Table 2. Morphometric measurements of the Common hepatic duct and the common bile duct (Choledoch duct).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Length</th>
<th>Range mm</th>
<th>SD</th>
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</thead>
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<td>Common hepatic duct</td>
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<td>19.1-47.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Diameter of common hepatic duct</td>
<td>4.6</td>
<td>3.2-8.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Choledoch</td>
<td>60.6</td>
<td>41.9-81.1</td>
<td>9</td>
</tr>
<tr>
<td>Common bile duct diameter</td>
<td>5.6</td>
<td>3.9-10.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Common bile duct (supra duodenal)</td>
<td>15.5</td>
<td>5.5-28.7</td>
<td>6</td>
</tr>
<tr>
<td>Common bile duct (retro duodenal)</td>
<td>29.3</td>
<td>19.2-36</td>
<td>3.9</td>
</tr>
<tr>
<td>Common bile duct (intra pancreatic)</td>
<td>18.5</td>
<td>4.2-63.9</td>
<td>12.4</td>
</tr>
</tbody>
</table>

In 3 anatomical blocks (9.1%), AHD was observed; in one sample, the AHD joined the CD, presenting a length of 9.27 mm and a diameter of 0.98 m (Figure 3); and in another case it joined the CHD with a length of 30.8 mm and in another sample it joined the body of the gallbladder.

In 29 samples (87.9%) medium length CD was observed, while in 4 cases (12.1%) the CD was long, this being a statistically significant difference (P < 0.05). It was not observed CD with a length less than 10 mmm. The trajectory of the CD was lateral oblique in 23 cases (69.7%), lateral oblique and sinuous in 5 (15.1%) (Figure 1, 4). It was observed parallel and lateral trajectory in 2 cases (6.1%), lateral and sinuous parallel in one case (3%) and medial...
oblique in two cases (6%) (Figure 5). Statistically significant differences were observed between the lateral oblique path in relation to the other trajectories of the CCI (p < 0.05)

In 18 specimens (55%), the cystic-hepatic union was observed at the level of the middle third of the EBD, while in 15 (45%) cases it was at the low third level. (P< 0.05) In the sample evaluated, there was no CD with high third level unions.

Discussion

The length and width dimensions of the GB found in our study, 66.9 mm and 9.4 mm respectively, are similar to those reported in Latin American population samples [4, 15]. Slightly larger GB dimensions have been reported in other population groups [18]. No anatomical variations of GB were found in relation to their location and number, probably because of the sample size. These variations have been reported in a very low incidence in other population groups [3]

The presence of Hartman’s pouch was observed in 50% of the cases, in agreement with that reported by Van Eijck, F.C., et al. 2007 [19], and considerably less than that described by Cavalcanti Jennecy Sales, et al. 2002 [4] of 74% in the study of cadaveric material. We emphasize the scarce evaluation and information on this anatomical structure in previous studies regarding its incidence and biometry. The presence of this structure constitutes an anatomical substrate of the events of cholelithiasis, because the so-called biliary sludge, characteristic of GB with dyskinesia, tends to solidify at the level of the HP, causing the onset of stones of different sizes and numbers [19]. Also, during cholecystectomy procedures, Hp can hinder the identification of CD and other structures of the bile duct, increasing the likelihood of iatrogenesis at this level.

Previous studies [5, 15] reported dimensions in the range of 16.1-17.7 mm for the RHD and 15.2-28.5 mm for the LHD, which are greater than those obtained in our series. These differences can be attributed to the size of the samples evaluated in the various studies and to the measurement methodology.
The length of CHD has been reported in studies with cadaveric material, cholangiopancreaticography and magnetic resonance imaging-MRI [5, 14, 15] in diverse population groups in a range of 19.1-36 mm, dimensions that are in accordance with our measurements (28.6 mm). The long CHD evidences a low cystic-hepatic union, which is beneficial when performing surgical interventions that can compromise the hepato-biliary tract.

The frequency of AHD observed in our study (9.2%) is similar to that reported by Devi, T and P. Krishna 2013 [20]. Other studies have reported incidences of 0.7-6% [6, 12, 15, 21]. It is highlighted that Cachoeira et al 2012 [14] did not report AHD. AHD have not been associated with increased pathology of EBD and are reported as autopsy findings, but in surgical procedures their inadequate recognition or approach can lead to a significant increase in morbidity and mortality [3].

The length of the CD found in our study is located in a mid-range in relation to the previous reports (19.1-35 mm) [14, 15, 22] while the diameter is consistent with that reported in the literature. [14, 15, 23]. The incidence of medium-sized CD (87.8%) found in the present study is significantly higher than that reported by Kayat et al 2014 [5]; Likewise, the CD greater than 40 mm, in the present study was observed in 12.2%, concordant with that reported by Sirisha et al 2017 [24], while other authors have reported it in a range of 1.7-5.3% [7, 8]. The short CD, less than 10 mm, has been reported in a range of 2-20% [5, 6, 7, 8, 24]. It is highlighted that this presentation of the CD was not observed in the present study. In the cholecystectomy procedures, the short CD generate the possibility of iatrogenic because the clip installed in this structure presents a greater risk of loosening. [12]. A long CD may be associated with inflammatory processes, with stone formation and errors in the interpretation of diagnostic images [25].

The trajectories of the oblique lateral and oblique CD observed in this series in 84.8% are concordant with previous studies [15, 23], as well as the low incidence (6.1%) of the parallel trajectory [4, 9]. Posterior and medial trajectory was found in only one case (3 %), while in previous studies it was reported in a range of 12.8-16.9%. [9]. We highlight the findings of Bercy 1992 [12] with angiographic material in the Anglo-Saxon population group that are not in accordance with what is reported in the literature and that records 17% for lateral oblique trajectory, 41% for posterior and 35% for posterior and medial trajectory. When the CD has a course parallel to the CHD, both can be wrapped by a fibrous sheath, which may have an impact on the CHD lesion during cholecystectomy [25].

Given the evident variability of the trajectories of CD it is necessary to perform imaging studies that provide information prior to surgical procedures that compromise the bile duct; However, for emergency surgical approaches it is important that surgeons have a broad knowledge of the morphological expressions of these structures.

The length and diameter of the ChD registered in this series (60.6 and 5.29 mm, respectively) are in a mid range compared to the few previous reports [5, 15]. No reports were found regarding measurements of the supraduodenal, retroduodenal and intrapancreatic segments of the ChD, so the findings recorded in the present study constitute a contribution to the detailed biometrics of the EBD.

Studies performed on cadaveric material and with diagnostic images do not provide clear criteria for determining the level of the union of CD to CHD, thus making the results difficult to compare. In the present study the length of the EBD was determined by the sum of the lengths of the CHD and the supraduodenal segment of the ChD, and the overall length was divided into thirds that accurately determined the level of the hepatic cystic junction, a methodology that we propose be considered in future investigations.
In our series, the highest frequency of union of the CD (55%) with the EBD was in its middle third, in accordance with some previous reports [9, 26]. In our study, we did not find cysto1hepatic unions in the upper third, an anatomical characteristic that has been reported in a range of 2-5.5% [8, 9]. It stands out the incidence of 73.3% reported by Khayat, Meiaad F., et al 2014 [5]. The low third unions observed in this study (45%) are considerably higher than the previous reports (7-18%) [3, 4, 9, 12]. The wide range of variability observed when registering the results of the studies that deal with the anatomical characteristics of the EBD can be explained by the biological differences of the population groups evaluated, the size of the samples and the various measurement criteria.

Conclusions
The determination of the length and mathematical distribution of the upper, middle and lower thirds of the EBD, carried out in this study, is useful in assessing the level of the cystic-hepatic union, fills a methodological void observed in previous studies and provides reliability to the results presented. The morphometric findings of the present study constitute a significant contribution to the detailed biometrics of EBD.

Characteristics of the EBD, such as the high incidence of the lateral oblique trajectory of the CD, low presence of the trajectory in parallel of this structure, as well as the moderate presentation of the Hartmann’s pouch observed in this study, are in accordance with that reported in the literature; while the presence of long ABD and CDs is greater than that reported in previous studies.

Given the high variability of the EBD and the presence of complex clinical-surgical events that characterize it, a good anatomical knowledge of these structures is required, especially when performing emergency room procedures.

General comment & Originality
The investigators authors of this article declare that it is an original work and participated in all the phases of its preparation. No conflict of interest.

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References