

## Anatomical study of the intrahepatic biliary ducts. Parameters that guide the surgical approach in transplanting the left lobe of the liver

F. FARIAS<sup>1</sup>, A. VICENTE BIGOLIN<sup>2</sup>, L. TOTTI CAVAZZOLA<sup>3</sup>, O. PEREIRA DA COSTA FILHO<sup>1</sup>, R. GONÇALVES DA COSTA<sup>1</sup>, A. NOCCHI KALIL<sup>2</sup>

**SUMMARY:** Anatomical study of the intrahepatic biliary ducts. Parameters that guide the surgical approach in transplanting the left lobe of the liver.

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**Introduction.** *The techniques of split liver transplantation and transplanting organs from living donors require a thorough anatomical knowledge of biliary drainage, and this is an important factor in preventing complications.*

**Methods.** *forty-five human livers were used to perform this study. Measurements were made between the confluence of the right hepatic duct (RHD) and the left hepatic duct (LHD) and among the following structures: the venous ligament, the vertex of the confluence of the duct*

*of segment II (DSII) and the duct of segment III (DSIII), the insertion of the duct of the segment I (DSI) and the duct of segment IV (DSIV). Then the distance between the vertex of the confluence of DSII and DSIII and the ligamentum venosum was checked.*

**Results.** *The LHD had less anatomical variation than the RHD. Four drainage patterns were established for the left lobe, and pattern I, in which the confluence of DSII and DSIII is to the left of the ligamentum venosum, is considered to be the most constant one. A single duct of the confluence of DSII and DSIII was found 1, 2 and 2.5 cm to the right of the ligamentum venosum in 65%, 80%, and 95% of the cases, respectively.*

**Conclusion.** *It was possible to show evidence of four drainage patterns of the left anatomical lobe of the liver. Furthermore, it was possible to establish the ligamentum venosum as an anatomical reference for locating the confluences of the ducts of the left liver segments.*

KEY WORDS: Liver transplantation - Anatomy - Living donor liver transplantation.

### Introduction

Progress in the knowledge of hepatic anatomy is proportionally related to changes in the evolution of liver transplant techniques. The anatomical segmentation that was defined by Couinaud has guided procedural conduct regarding the procedures for hepatic resection since 1957 (1, 2).

The anatomical importance of the intrahepatic biliary ducts came up again in the late 1980s due to the advent of liver transplantation from living donors (2, 3). Furthermore, the technique of Split-Liver transplantation allows a single organ from a cadaveric donor to be

shared by two living recipients if one is a pediatric recipient while the other is an adult. In both of them the need exists for resection of the parenchyma and performance of multiple anastomoses of intrahepatic bile ducts. Taketomi et al. reported a 4.1% incidence of postoperative biliary complications in donors (5). An understanding of the anatomy of the biliary tree and its main variations is essential to reduce the rate of biliary leakage and lessen morbidity related to the procedure (6, 7). In this context, increased safety may be provided by following the simple rule that the fewer anastomoses there are, the fewer complications there will be. Thus the determination of the points of confluence of the drainage ducts of each segment is of utmost importance.

Despite the emphasized importance in liver transplantation, studying the anatomy of the biliary duct is essential in any surgery involving this organ. Many authors advocate the routine performance of retrograde cholangiopancreatography before any hepatic resection (8). This statement gains strength when donors are still living, where more severe anomalies may also contraindicate the procedure.

<sup>1</sup> Lutheran University of Brazil - ULBRA, Brazil  
Department of Surgery

<sup>2</sup> Irmandade Santa Casa de Porto Alegre - ISCMPA, Brazil

<sup>3</sup> Universidade Federal do Rio Grande do Sul - UFRGS, Brazil

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## Methodology

The objective of this study was to evaluate the anatomy of the biliary drainage of the left lobe of the liver through relevant parameters in hepatic resection. These parameters are specified above:

1. Define relationships and distances between the confluence of the main bile ducts involved in the drainage of the left lobe, also noting its relationship with ligamentum venosum of the liver.
2. Evaluate the confluence of the right hepatic duct (RHD) and the left hepatic duct (LHD), and the anomalies thereof.
3. Evaluate the patterns of drainage of the duct of segment I (DSI) and the duct of segment IV (DSIV). This study evaluated cadaveric human livers extracted within a period of up to 24 hours after death. The specimens were obtained from the Department of Forensic Medicine of Porto Alegre - RS. Approval was obtained from the Research and Ethics Committee prior to the beginning of the study.

Forty-five organs were used, all of which were removed, during the autopsy while preserving the hiliary vascular pedicle, from the inferior vena cava above the renal veins and below the right atrium. Some were excluded from the sample, more specifically those which had macroscopic changes in their anatomy, inadequate collection with the loss of or damage to important structures, evidence of or background of liver disease or trauma, and inaccurate information regarding anthropometric data about the cadaver.

### Analysis of samples

The samples were not fixed, and their preservation was performed by freezing. They were only washed with running water. Then the preparation of the organ began with resection of adjacent tissues and repairing of venous and round ligaments as well as the portal vein and the hepatic artery. The cystic duct was ligated and then, through cannulation of the common bile duct, green English vegetable dye 37 was injected into the biliary tree.

The structures of the hepatic hilum were dissected, paying attention to the anterior-posterior syntopy. The proximal branches of both vascular portions were dissected and then the main bile duct was exposed by removing the hilar plate. The segmental ducts of the

left biliary tract and the main tributaries of the right tract were observed.

The next step included checking the measurements between the vertex of the confluence of the right hepatic duct (RHD) and the left hepatic duct (LHD) and the following structures: the venous ligament, the vertex of the confluence of the duct of segment II (DSII) and segment III (DSIII), and insertion of the duct of the segment I (DSI) and IV (DSIV). Then the distance between the vertex of the confluence of the DSII and DSIII and ligamentum venosum was checked. Figure 1 summarizes the steps of analysis of the part (Fig. 1).

The results were analyzed using SPSS version 11.0 for Windows.

## Results

Forty-five human livers were selected, based on inclusion and exclusion criteria for this study. Of these, 40 livers were evaluated, while the others (n=5) were excluded due to the observation, in one case, of an appearance suggestive of fibrosis that was not observed in the initial stage, and due to damage to the bile duct during dissection of the other parts.

The sample consisted mostly of males (90%). The predominant ethnic group was Caucasian (75%), and the mean age was 39.5 years.

In 60% of the sample, the RHD was a single duct with a well-defined trunk. A trunk that was short or bifurcated split was found in 30%. In 7.5% of cases, there was no RHD and the main biliary confluence was formed by three bile ducts that originated in the right side of the liver, beyond the left biliary tract. In only one case, a duct originated in the right lateral posterior sector flowed into the LHD to the left of the middle hepatic fissure

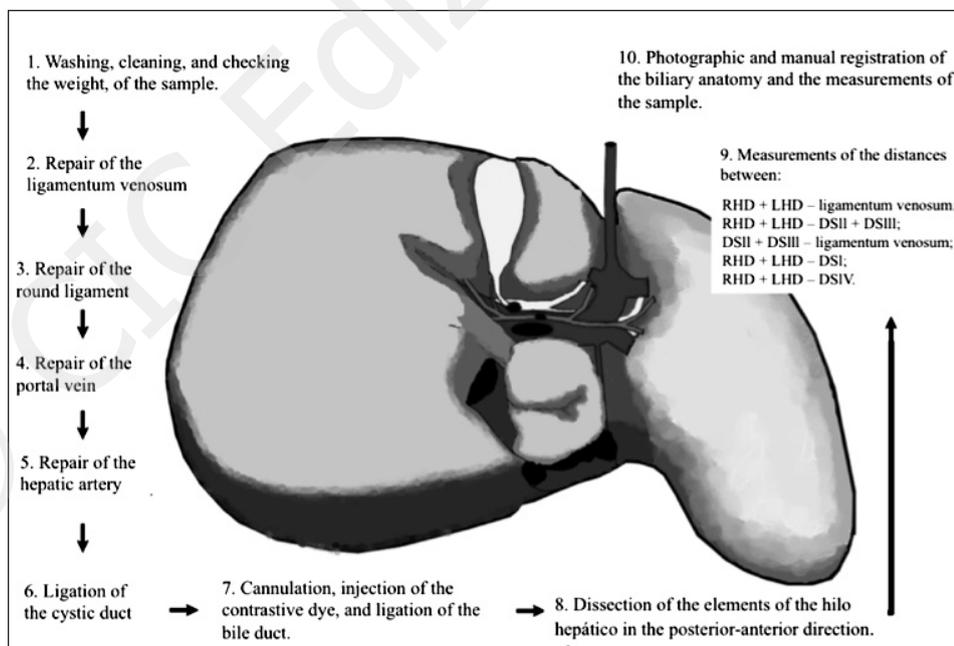


Fig. 1 - Summary of the actions taken in preparing and evaluating the liver.

RHD+LHD - lig.venosum - distance between the confluence of the right and left hepatic ducts and the ligamentum venosum; RHD+LHD-DSII+DSIII - distance between the confluence of the right and left hepatic ducts and the confluence of the ducts of segments II and III; DSII+DSIII-lig.venosum - distance between the confluence of the ducts of segments II and III and the ligamentum venosum; RHD+LHD-DSI - distance between the confluence of the left and right hepatic duct or ducts of segment I; RHD+LHD-DSIV - distance between the confluence of the right and left hepatic duct or ducts of segment IV.

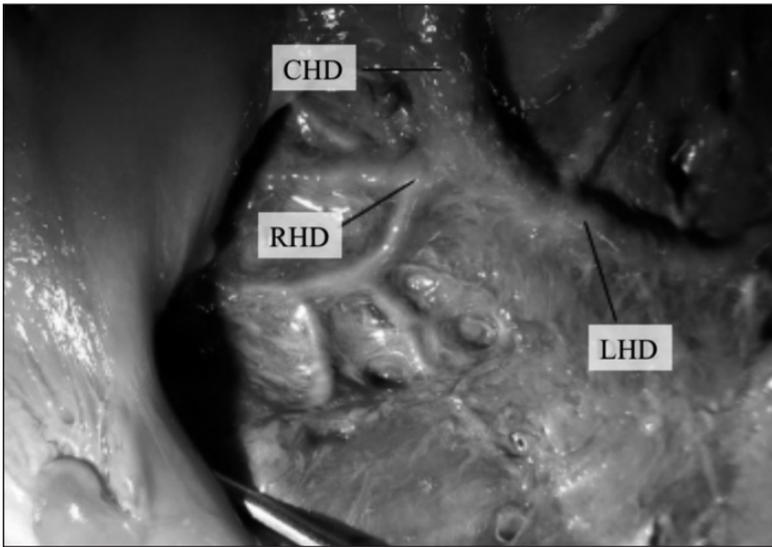


Fig. 2 - The left biliary passage does not receive biliary ducts from segment I, and it was drained exclusively by the right hepatic duct.  
CHD – Common Hepatic Duct; RHD – Right Hepatic Duct; LHD – Left Hepatic Duct.

(the Cantlie line). The LHD was present in 90% of the parts in a single, well-defined shape, whereas in 10%, of them, it was bifurcated or had a short trunk.

Regarding segment I, in three samples (7.5%), the drainage was done solely for the RHD (Fig. 2). In other cases, the drainage was done for the LHD by 5, 4, 3, 2 or 1 duct in 7.5%, 5%, 20%, 40% and 20% respectively of the total parts evaluated. The drainage of segment IV was carried out through the LHD in all cases, and it was most commonly performed through just one duct (50%) and through 2 in 40% by, through 3 in 7.5%, and through 4 in only 2.5% of the cases.

The evaluation of the confluence of the DSII and the DSIII allowed for defining four patterns of drainage of the left anatomical hemi-liver (Fig. 3). In pattern 01, the confluence of the DSII and the DSIII was to the left of the ligamentum venosum and corresponded to 45% of the dissected parts. In pattern 02 (17.5% of the cases), the confluence of the DSII and the DSIII was to the right of the venous ligament in the distal third of the distance between the confluence of the RHD and the LHD with the ligamentum venosum. In pattern 03, corresponding to 27.5% of the sample, the confluence of the DSII and the DSIII also occurred to the right of the venous ligament, in the middle third of the distance between this ligament and the junction of the RHD and the LHD. In pattern 04 (10% of the livers), there was no left hepatic duct or there was a short, bifurcated trunk in DSIII and DSIV and DSI and DSII, although in one case there were two DSIVs, and one of them entered the LHD near its confluence with the RHD.

The analysis of the confluence of the DSII and DSIII in relation to the venous ligament could determine a bimodal presentation through a Gaussian curve, where in 55% of the livers the confluence is shown to be to be at

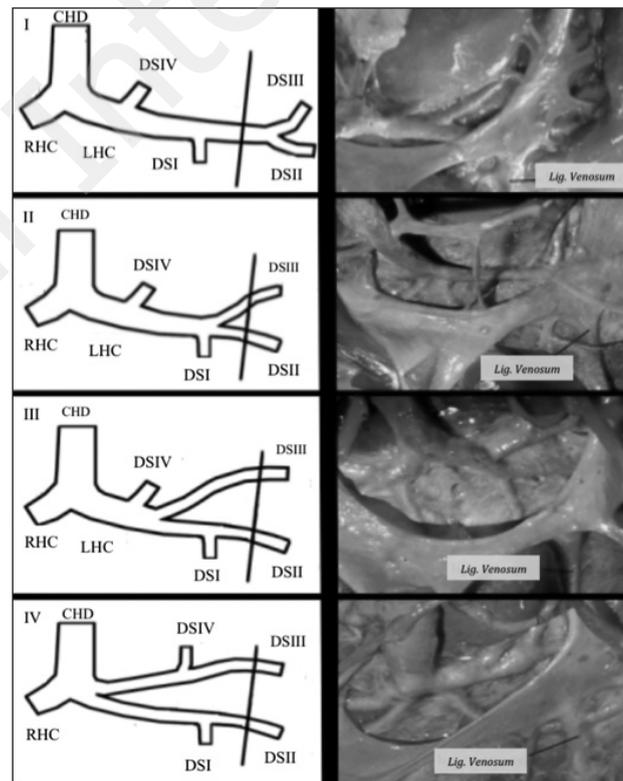


Fig. 3 - Patterns of drainage of the LHD according to the confluence of DSII and DSIII. \* In the image of pattern two, the confluence of the ducts of segments II and III is shown in the form of a shadow, since where it is found it is covered by the left portal vein.  
CHC – Common Hepatic Duct; RHD – Right Hepatic Duct; LHD – Left Hepatic Duct; DSI – Duct of Segment I; DSII – Duct of Segment II; DSIII – Duct of Segment III; DSIV – Duct of Segment IV. The black line represents the Ligamentum Venosum in the sketches.

the right side of the ligament (Fig. 4). A single duct representing the confluence of the DSII and the DSIII was encountered 1 cm to the right of the venous ligament

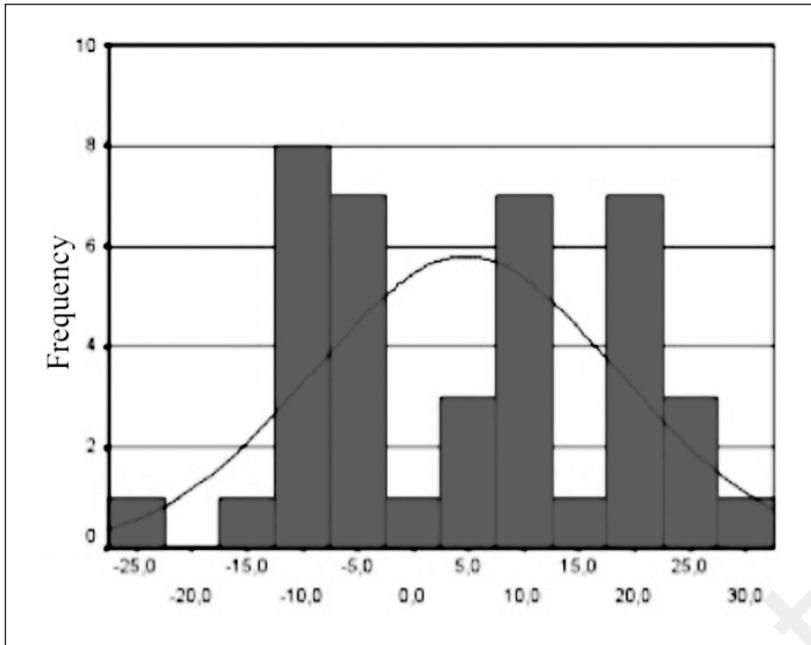


Fig. 4 - Bi-varied data of the distance of the confluence of the DSII and DSIII in relation to the ligamentum venosum. In the table we can see the discrimination of the results noticed in the graph. Positive data are found at the right of the ligamentum venosum; Negative data are found at the left of the ligamentum venosum.

in 65% of the cases. The same single duct can be found in 80% and 95% of cases at a point 2 cm and 2.5 cm to the right of the venous ligament, respectively.

The relationships between the measurements are shown in Tables 1 and 2.

## Discussion

The peculiar anatomical and functional segmentation of the liver is associated with a large number of variations among its components, whether they are vascular components or those for biliary drainage. The recognition of these peculiarities is mandatory in the surgical treatment of liver disorders.

In this study greater variability was observed in the analysis of the RHD in relation to the LHD, being respectively 40% and 10% of cases. This result makes it possible to reference the left lobe of the liver with less

difficulty from the standpoint of biliary anatomy in order for it to be involved in a transplant. In a case where the hepatic size of the left lobe of the liver is sufficient, it should be regarded as the preference to carry out a transplantation in cases where both the donor and recipient are alive.

The evaluation of the LHD allowed the definition of relevant parameters regarding the location of the confluence point of the drainage of the segments of the left anatomical lobe of the liver. Such information is extremely important to obtain a single duct for anastomosis after liver resection. This approach may reduce postoperative complications when compared to surgery requiring anastomosis of two or more ducts (5).

In relation to the drainage of segment I, this study showed data that agree with the literature, which states that this can be drained by multiple ducts, two or three on average (1, 9, 10).

TABLE 1 - DISTANCES BETWEEN THE MAIN ANATOMICAL POINTS AS OBSERVED.

	N	Minimum	Maximum	Average	Standard deviation
RHD+LHD → Lig. Venosum*	40	22.22	61.06	35.22	8.42
RHD+LHD→DSII+DSIII**	40	3.15	56.20	30.51	13.46
DSII+DSIII→Lig. Venosum***	40	-22.84	27.63	4.74	13.74

\* Distance between the confluence of the right and left hepatic ducts and the ligamentum venosum, expressed in millimeters.  
 \*\* Distance between the confluence of the right and left hepatic ducts and the confluence of ducts of segments II and III, expressed in millimeters.\*\*\* Distance between the confluence of the ducts of segments II and III and the ligamentum venosum. The minus sign in front of the measurement represents the direction to the left side of the ligamentum venosum, expressed in millimeters.

TABLE 2 - GLOSSARY.

Acronym	Term
LHD	Left hepatic duct
RHD	Right hepatic duct
DSI	Duct of segment I
DSII	Duct of segment II
DSIII	Duct of segment III
DSIV	Duct of segment IV

Segment IV was drained exclusively to the RHD, in many cases by more than one duct. The junction of DSIV with the RHD occurred less than 1 cm from the union of the RHD and the LHD in 20% of the cases. This information is also of great importance for the treatment of hilar bile duct carcinoma, where the DSIV location closest to the hilum determines a premature invasion and the need for resection of the segment. According to Kawarada et. al. in 35.5% of cases, DSIV is inserted more closely to the liver hilum (11).

The definition of parameters of LHD drainage given by Coinaud is of minor value for liver transplantation procedures in relation to those for bile-digestive reconstruction (2). In this study, we were able to define four distinct patterns of LHD. These patterns can be considered similar to those of Coinaud, but in our classification, the confluence of DSII and DSIII was observed as a parameter in order to obtain the plane in which one may encounter a single biliary drainage duct from the left anatomical lobe of the liver.

Among the drainage patterns, the determined as type I, where the ducts were encountered at the left side of the ligamentum venosum, was the most prevalent. Similarly, in the clinical and pathological study of Reichert et al. al, four drainage patterns were defined and the most frequent pattern, was the confluence of the ducts at lateral side of the umbilical fissure (12). Ohkubo et al. al. also found that the most prevalent pattern was the confluence of DSII and DSIII in a more medial location (13). These data give credibility to use of the technique of transplantation of the left anatomical lobe, since when the approach is performed medially to these mentioned anatomical reference points, it tends to find only a single duct. This approach requires only one anastomosis and because of the large size of the duct at this point, it is easiest to perform. These factors are directly linked to reduction of postoperative complications.

More precisely, Reichert also stated that a sectioning of the hepatic parenchyma in a plane that was traced to one centimeter to the right of the umbilical fissure will a single duct of the left lobe in 90% of cases (2). In this study however, at the same distance from the ligamen-

tum venosum, a single duct was found in 65% of cases. This finding emphasizes the need for greater caution because at this distance 35% of confluence can still be found. A 1 cm change from the plane of resection, in other words, more than 2 cm to the right side of ligamentum venosum can significantly increase the prevalence of a single duct.

Onishi et al, showed that there is an average distance of 9.7 mm between the confluence of the DSII and DSIII and the umbilical portion of the portal vein, but they did not define the patterns of convergence (14). In our study a greater proximity to the reference point was observed, with an average of 4.74 mm to the right of the ligamentum venosum. Regarding the studies cited above, the ligamentum venosum, despite having close relationship with the umbilical fissure, was shown to be a more frequent parameter due to less variability between the measurements for each sample. Also this ligament has an anatomical location that is easier and more accurate.

The influence of hepatic anatomy influences not only the techniques of liver transplantation, but also all surgical procedures that involve resection of the parenchyma of the organ. Currently with the evolution of minimally invasive techniques, the laparoscopic technique is on the rise. The loss of tactile sensitivity of this technique can be compensated by the accurate determination of the topography of the liver.

## Conclusions

The evaluation of the results shows that it was possible to determine, based on the confluence of the DSII and the DSIII, the biliary drainage of the left anatomical lobe of the liver through four patterns. The most frequent pattern showed the confluence of the ducts in a location that is more medial and to the right of the ligamentum venosum.

Regarding the specific objectives of this study we have:

- 1) The confluence of the DSII and the DSIII, with the most significant prevalence at 2.5 cm from the liga-

mentum venosum. The average distance was 4.74 mm to the right of the same ligament. The confluence of LHD and RHD met at a point 35.22 mm from the ligamentum venosum, on average. The confluences of the LHE and RHS and the DSII and the DSIII were at a distance of 30.51 mm on average.

2) The LHD was shown to have an anatomy with fewer

anatomical variations than that of the RHD.

3) DSI was shown to have varying aspects, including drainage for the RHD in some cases. However the presence of two ducts draining this segment was the most common. Segment IV was drained into the LHD in all the cases, and it was mostly drained by only one duct.

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