Intrahepatic Bile Duct Anatomic Variations among Egyptians: A Magnetic Resonance Cholangiography Study

Running Title: IHBD Anatomic Variations

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ABSTRACT

Background: The history of end-stage liver diseases has been changed by liver transplantation. Egypt's high prevalence rate of liver diseases has increased the number of patients requiring liver transplantation. Living donor liver transplantation has many advantages over deceased donor liver transplantation; nevertheless, biliary complications, which are the commonest intractable problem, are more likely to occur after living donor liver transplantation. Magnetic Resonance Cholangiography is a non-invasive method to assess the biliary system's anatomy.

Objective: In this study, we aimed to assess the anatomic variations of the biliary tree among the Egyptian population using Magnetic Resonance Cholangiography.

Patients and Methods: We conducted this study on 353 patients who underwent MRC procedures between May 2010 and December 2015. Anatomical variations of intrahepatic bile ducts were studied based on the variable insertion of the right posterior hepatic duct according to Huang classification; moreover, the presence of accessory ducts was also noted.

Results: Based on the Huang classification, variations were divided into five types.Type 1 (typical type) occurred in 207 cases (58.6%) while type 2 (triple confluence) occurred in 61 cases (17.3%). Type 3, Type 4, and Type 5 were noted in 66 cases (18.7%), 14 cases (4%), and 5 cases (1.4%). We observed accessory duct in 14 cases (4%of all studied cases).

Conclusions: ***Our findings provide a precise understanding of the variations of the intrahepatic bile ducts among Egyptians. This is important for both donors and recipients to ensure a successful liver transplant and reduce subsequent biliary complications.***
Keywords: ***Intrahepatic Bile Ducts; Liver transplantation; MR cholangiography; Complications***

1 Introduction

Liver transplantation has improved the natural history of end-stage liver diseases and is now regarded as the best treatment for multiple formerly fatal chronic and acute hepatic diseases(1,2). The major disorders that may need liver transplantation include advanced Cirrhosis, Budd Chiari syndrome hepatocellular carcinoma, liver-based metabolic diseases, and some cases of acute liver failure (2). Previous literature reported that the highest prevalence of hepatitis C virus is in Egypt (14.7%)(3). Egypt has the largest percentage of liver transplantation in the Arab world. The most common indication for liver transplantation was end-stage liver cirrhosis due tothe hepatitis C virus with or without hepatocellular carcinoma(4).

Living donor liver transplantation has numerous advantages over deceased donor liver transplantation. The advantages include the more number of available organs, lesser morbidity and mortality rates,as well as lower costs (5). Nevertheless, biliary complications commonly occur after living donor liver transplantation, and they remain the most frequent problem (6–8).In both LDLT donors and recipients, these complications result inconsiderably higher morbidity and mortality rates; they occur in almost 30% of cases (9). Detailed intrahepatic bile duct anatomy is crucial to ensure donors' safety in LDLT and decrease postoperative complications and morbidity in recipients(10,11).

Magnetic Resonance Cholangiography (MRC) is a non-invasive accurate investigation for assessing the biliary system's anatomy and pathology(12). MRC is done with high resolution heavily T2- weighted sequences to augment the signal of stationary fluids in both biliary and pancreatic ducts with no need for either contrast material or ionizing radiation. With the MRC technique, the intra- and extrahepatic biliary ducts can be assessed rapidly, reliably, and safely (13).With increased frequency and demands of LDLT in Egypt, the current work aimed to describe the anatomical variations of the intrahepatic biliary ducts and determine the frequency of each variation among Egyptians using MRC to enhance the safety of LDLT and to reduce the possible postoperative biliary complications.

2 Patients and Methods

2.1 Patient Population:

We conducted a retrospective study on patients who had undergone MRC procedures at Alpha Scan Imaging Center, Cairo, Egypt, between May 2010 and December 2015. The MRCs included in the current study were conducted in relation to stone formations, cholecystitis, cholangitis, malignancies, and various investigations on the biliary tract or liver transplantation.

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Patients were fasted for 6 hours before the MRC procedure to diminishthe stomach and duodenum fluid secretions, reduce intestinal peristalsis, and promote gallbladder distension.

2.2 MRC protocol

We used a 1.5T scanner (GE, Signa Excite) to obtain all MRCs. The protocol compromises one set of 2D coronal thick slice fast spin-echo MRC (TR/TE= 4000 ms/901.1 ms) and a second set of 3D oblique coronal thin slice fast spin-echo T2-weighted image MRC (TR/TE= 5454.6 ms/551.4 ms, spatial resolution = 0.66mm×0.66 mm×2.8 mm). Images data were post-processed to recreate maximum intensity projection images and multiplanar reformatted images.

2.3 Image interpretation

We traced the right posterior hepatic duct insertion in all cases andclassified patients based on the Huang classification (14) (**Figures 1-5**). Moreover, the presence of accessory ducts was also studied.

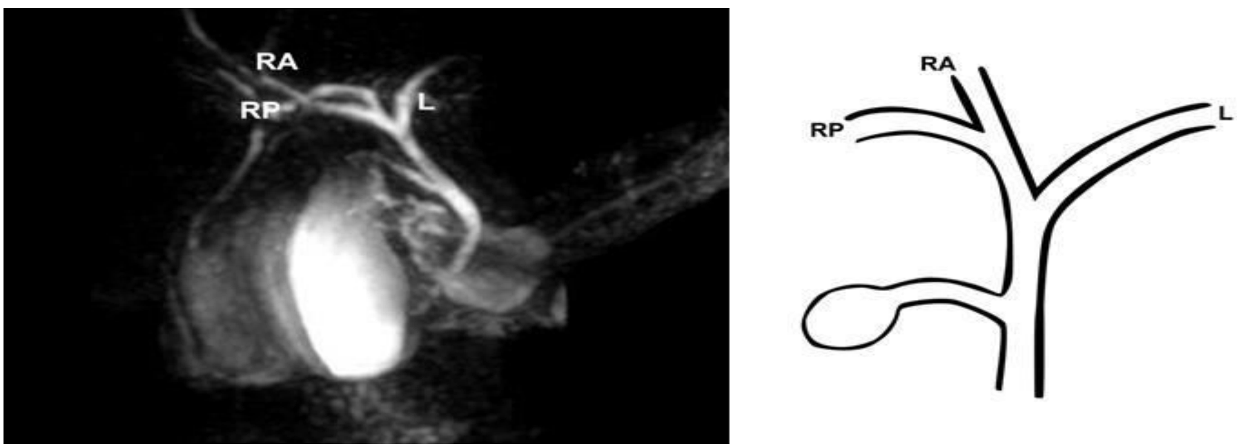

Fig. 1 shows type 1 (typical type). The right anterior (RA) segmental duct joins the right posterior (RP) segmental duct to form the right hepatic duct. The right hepatic duct joins the left (L) hepatic duct to form the common hepatic duct.

Fig. 2 showstype 2 (triple confluence). The right anterior (RA) segmental duct, right posterior (RP) segmental duct, and left (L) hepatic duct join simultaneously to form the common hepatic duct.

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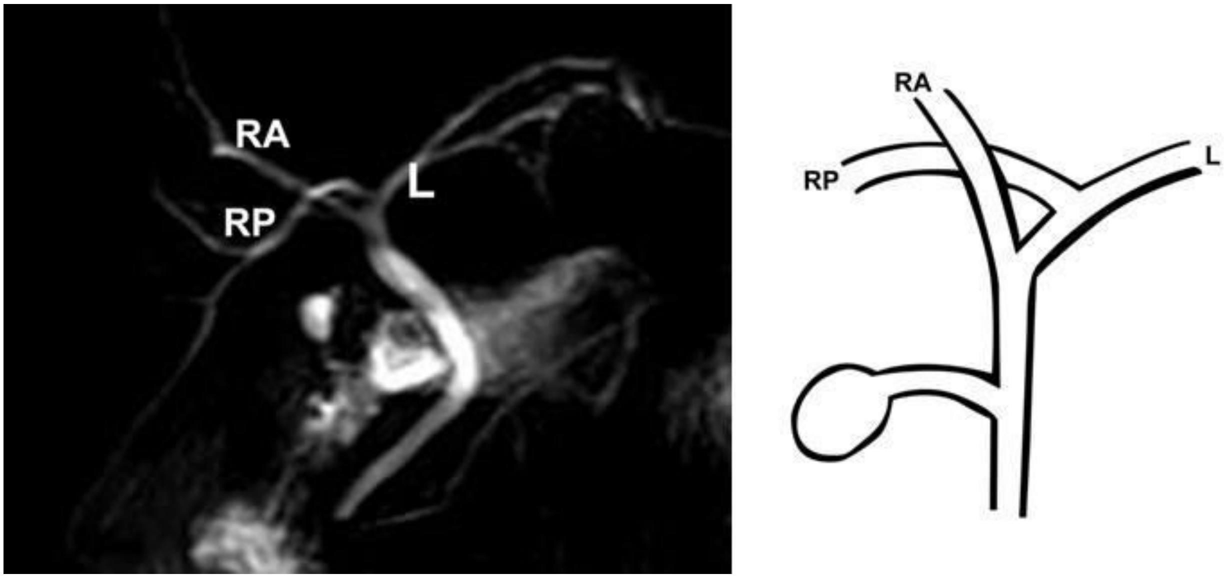

Fig. 3 showstype 3. The right posterior (RP) segmental duct joins the left (L) hepatic duct.

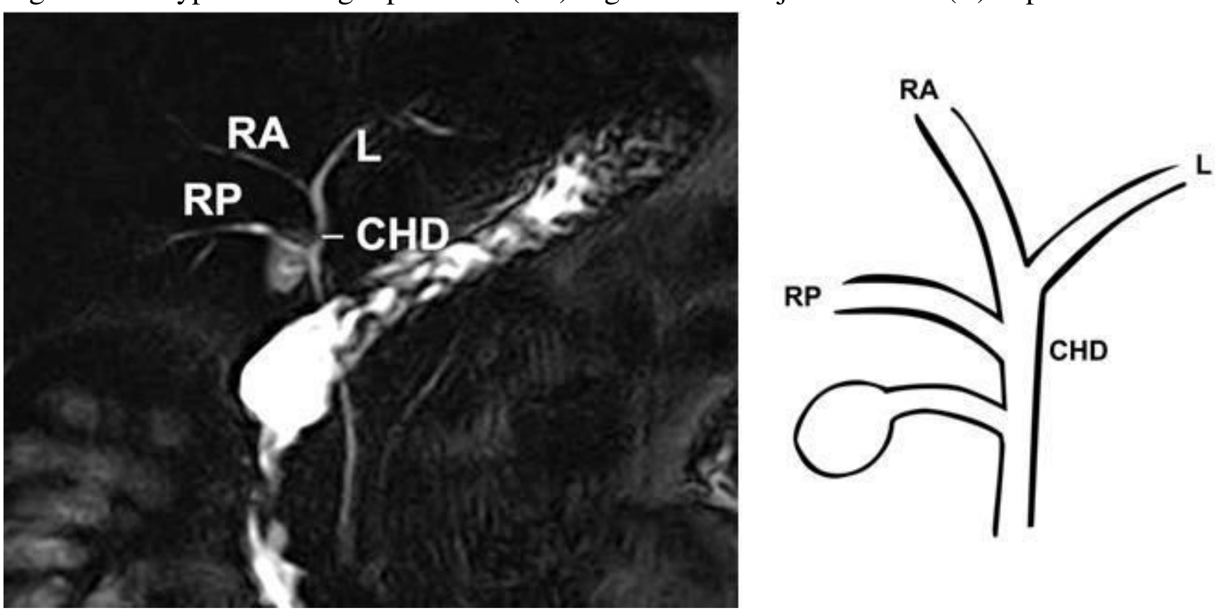

Fig. 4 showstype 4. The right posterior (RP) segmental duct drains into the common hepatic duct (CHD).

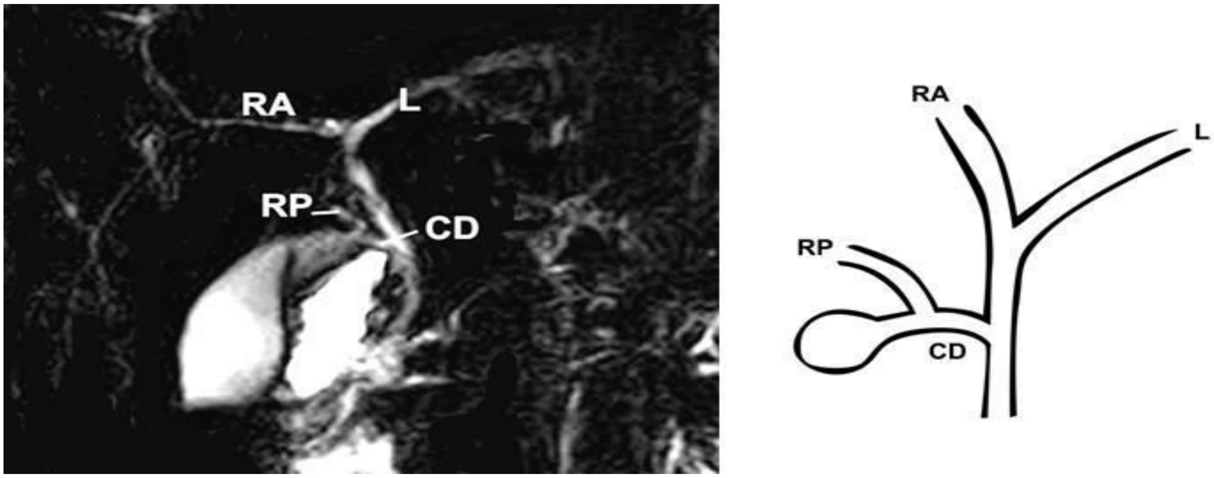

Fig. 5 showstype 5. The right posterior (RP) segmental duct drains into the cystic duct (CD).

3 Results

This study included 353 cases. According to Huang's classification, the Anatomic biliary duct variations were divided into five types. In the current study the frequencies of each type were as follows: Type 1: 58.6 % % (n =207), Type 2: 17.3 % (n =61), Type 3: 18.7 % (n =66), Type 4: 4 % (n =14) and Type 5: 1.4 % (n =5), as shown in Fig. 6.
In the current study, accessory hepatic ducts were found in 4% (n = 14) of total cases. Accessory ducts were found to drain into RASD (Fig. 7), CHD (Fig. 8), CD (Fig. 9).

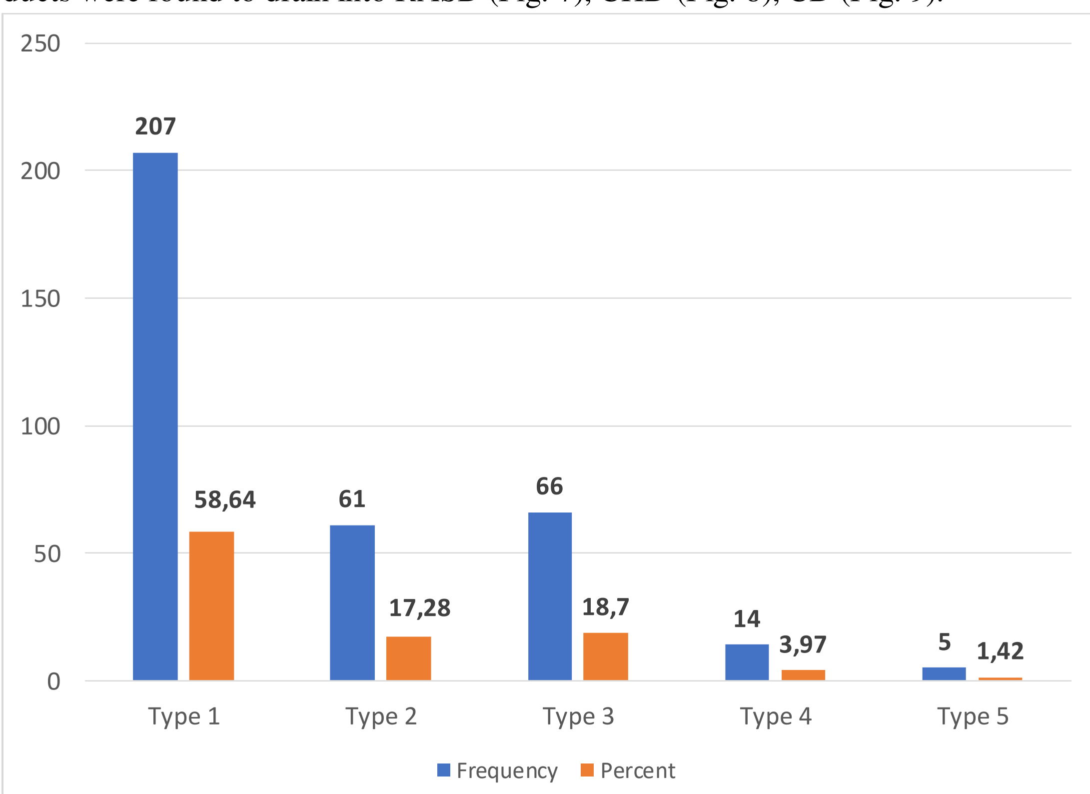

Figure 6: Huang types among the study participants.

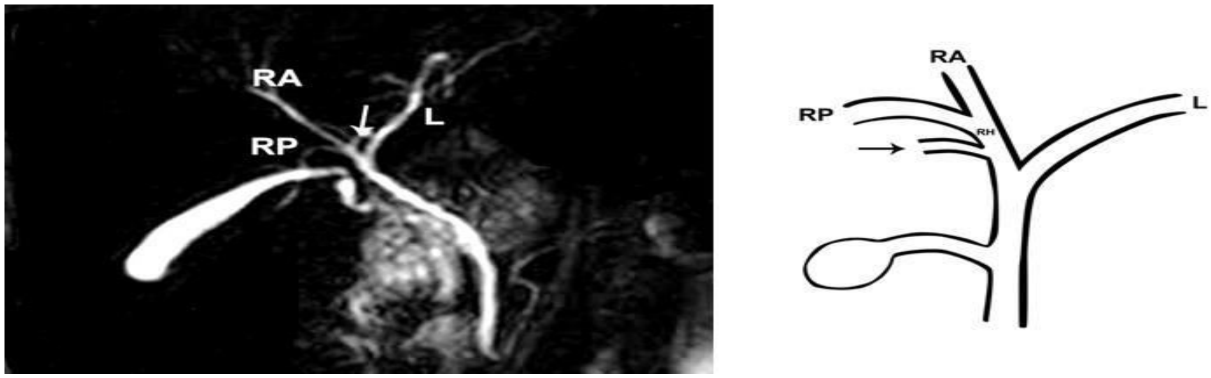

Fig. 7: Accessory duct (arrow) was found to drain into the right hepatic duct.

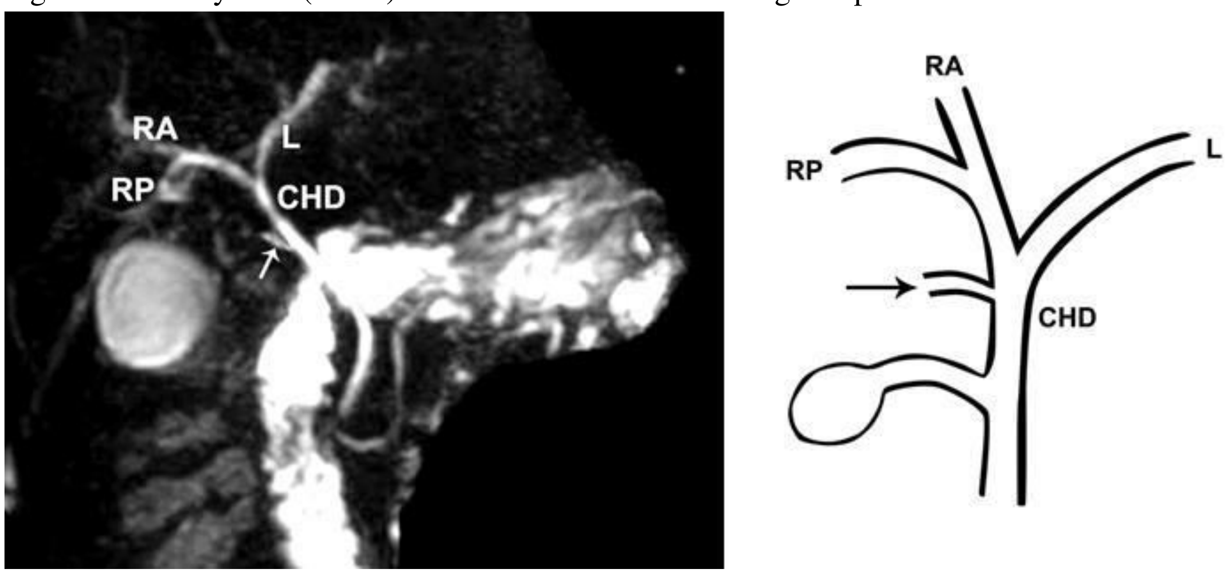

Fig. 8: Accessory duct (arrow) was found to drain into the common hepatic duct (CHD).

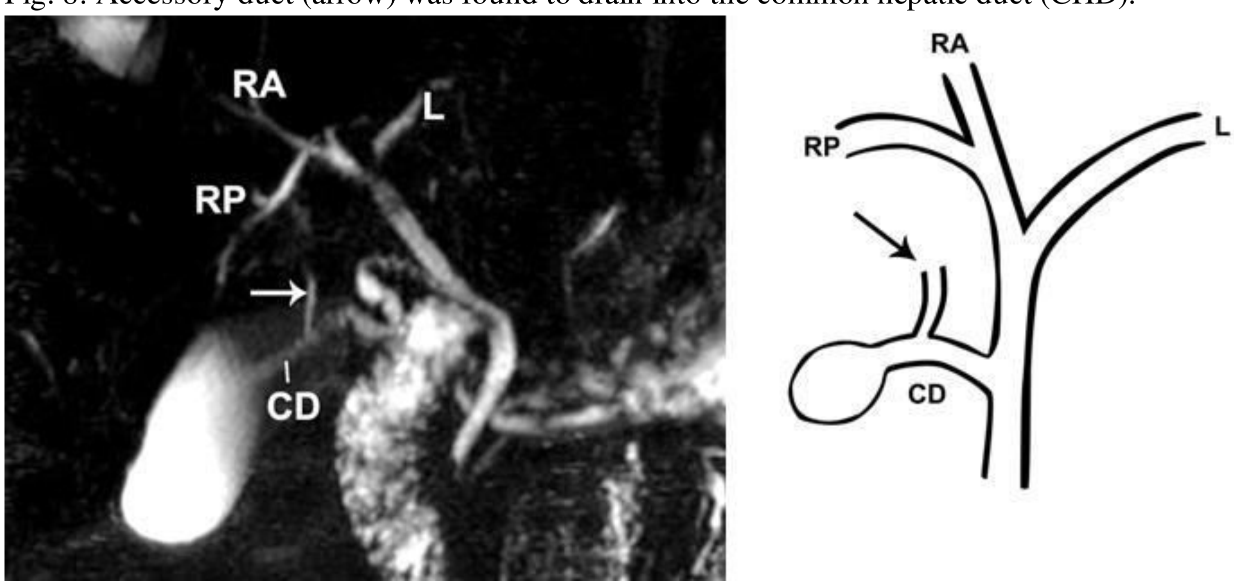

Fig. 9: Accessory duct (arrow) was found to drain into the cystic duct (CD)

4 Discussion

Precise knowledge of the anatomy of bile ducts and variations is crucial to safe LDLT,as pre-or intraoperative identification of the atypical or anomalous ducts allows for adjusting the surgical technique to avoid severe postoperative complications (9,15–19). Multiple techniques are used for imaging the biliary tract. These include transabdominal ultrasound, computed tomography, direct cholangiographic techniques such as endoscopic retrograde cholangiopancreatography,and indirect techniques such as magnetic resonance cholangiopancreatography (20). MRC has the advantage of being precise, non-invasive, and non-biohazardous in assessing hepatic vascular and biliary anatomy.

In this study, MRCwas used to assess the anatomical variants of biliary tracts in the Egyptian population. We observed thatin mostcases (58.6%), the anatomy of the intrahepatic bile ducts was type 1 or typical. Atypical branching patterns of intrahepatic bile ducts were found in (41.4%) of cases.The two most common variations were: type 2 or triple confluence, in which RASD, RPSD, and LHD join simultaneously to form the CHD (17.3%), and type 3, in which the RPSD join the LHD (18.7%). Other less common patterns include type 4, in which the RPSD drains into CHD (4%), and type 5, in which the RPSD drains into the cystic duct (1.4%).

Comparing our results regarding typical type & common variants with other authors:Choi et al. (2003)(21) observed type 1 in (63%); type 2 in (10%); type 3 in (11%). Ohkubo et al. (2004) (8) noted type 1 in (65%); type 2 in (5%); type 3 in (12%). Lyu et al. (2012)(22) found type 1 in (65.8%); type 2 in (9.1%); type 3 in (13%). Again, in the current work accessory hepatic ducts were detected in (4%) of total cases. The difference between aberrant and accessory hepatic ducts is that the aberrant duct is the only duct draining a segment of the liver while the accessory duct is an additional duct draining the same segmentof the liver (21).

However, in liver transplantation, accessory ducts are a minor factor in variation; they should never be overlooked. Identification of accessory ducts and proper surgical technique tailoring are essentialto avoid complications.Accessory duct ligation may lead to noticeable biliary obstruction, whereas dividing an accessory duct will result in bile leakage, biliary peritonitis, and late stenosis due to sclerotic action of the leaked bile. Biliary complications in living liver donors range from 0.4% to 13.0% and from 5.3% to 40.6% in recipients (10).

Conclusions

Our findings provide a precise understanding of the variations of the intrahepatic bile ducts among Egyptians. This is important for both donors and recipients to ensure a successful liver transplant and reduce subsequent biliary complications.

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List of Abbreviations

MRC	Magnetic Resonance Cholangiography
DDLT	Deceased donor liver transplantation
LDLT	Living donor liver transplantation
RPHD	Right posterior hepatic duct

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