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Original article

Anatomic variants of intrahepatic bile ducts in Thais

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Background: The progress in development of hepatobiliary surgical procedure has made understanding of the normal and variations of bile ducts important.
Objective: We determined anatomical variation of intrahepatic bile ducts in detected on magnetic resonance cholangiopancreatography (MRCP) at King Chulalongkorn Memorial Hospital in Thai people in order to perform interventional procedures and/or hepatobiliary surgery safely.
Method: One hundred sixty three Thai subjects were examined by MRCP at KCMH between January 1, 2003 and November 30, 2008. Images of MRCP retrieved were reviewed and classified as type A, conventional pattern; type B, trifurcation; type C, right posterior segmental duct (RP) joining common hepatic duct (CHD); and type D, right posterior segmental duct (RP) joining left hepatic duct (LHD).
Results: The anatomy of the intrahepatic bile ducts was typical (type A) in 65% of cases (n=106). Variations from conventional intrahepatic bile duct anatomy were seen in the remaining 57 patients, showing trifurcation (type B) in 17.2% (n=28), anomalous drainage of RP into CHD (type C) in 5.5% (n=9) and drainage of RP into LHD (type D) in 9.2% (n=15). Other variations in 3.1% (n=5) included the presence of an accessory duct and drainage of RP into common bile duct.
Conclusion: The branching pattern of intrahepatic bile ducts was atypical in 35% of cases. The highest incidence of variation is type B or trifurcation. Our results confirm previous reports. Variant intrahepatic bile duct anatomy is relevant for the practice of safe and efficacious surgical and other hepatobiliary intervention.

Keywords: Bile ducts, MRCP (magnetic resonance cholangiopancreato graphy), normal variants, Thai

Surgical procedures such as liver resections, partial liver transplantations, and laparoscopic cholecystectomy are increasing in frequency and complexity. Knowledge of normal biliary anatomy and variations are important for minimizing postoperative complications [7, 8, 12]. Moreover, if biliary damage occurs, imaging of the biliary system is required to determine appropriate interventions.

Magnetic resonance cholangiopancreatography (MRCP) is a non-invasive method for evaluating the hepatobiliary and pancreatic ductal systems. This technique provides images similar to those of endoscopic retrograde cholangiopancreatography (ERCP). MRCP has been shown to be accurate in displaying normal and abnormal conditions affecting the biliary ducts. It is becoming the modality of choice for non-invasive evaluation of the biliary tract [7]. By using heavily T2-weighted sequences, the relative high signal intensity of static or slow-moving fluid-filled structures such as the bile and pancreatic ducts is seen, resulting in increased duct to background contrast [13-15].

Although ERCP is still the standard for imaging the hepatobiliary and pancreatic ductal systems, there are many advantages of MRCP over ERCP. MRCP is noninvasive, less costly, uses no radiation, requires no anesthesia, is less operator dependent, allows better visualization of ducts proximal to an obstruction, and allows detection of extraductal disease when combined with conventional T1- and T2-weighted sequences [10-15].

Material and methods

We reviewed MRCPs obtained at the Department of Radiology retrospectively. A total of 163 cases (68 men, 95 women, mean age 59.8 years) were examined between January 1, 2003 and November 30, 2008, and were included in this study.

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We excluded patients who had undergone previous biliary surgery, liver resections, had congenital anomalies of the biliary system (e.g. choledochal cyst, caroli's disease), inadequate biliary tract depiction, and abnormalities of the hilar segmental bile ducts resulting in difficulty for characterization of biliary patterns.

MR examination including non-enhanced T1- and T2- weighted images and MRCP images were obtained with 1.5 T scanners (MR Signa Excite HD and MR Signa Horizon Echospeed, GE, USA). Displayed images were applied with single shot fast spin echo (SSFSE) T2WI technique with section thickness of 40 to 50 mm in coronal orientation.

Images of MRCP retrieved from PACS (Picture Archiving Computed System) were reviewed and classified into one of four types by an interpreting gastrointestinal radiologist (**Figure 1**).

Type A: conventional pattern that determined right posterior duct (RP) fused right anterior duct (RA) from left (medial) approach to form right hepatic duct (RHD), which then formed a junction with left hepatic duct (LHD) to form common hepatic duct (CHD).

Type B: trifurcation that determined emptying of RP, RA, and LHD into CHD.

Type C: drainage of RP to CHD (RA and LHD joined to form common trunk and RP joined distally).

Type D: drainage of RP to LHD followed by union with RA to form CHD

Other findings were grouped into new types or other variations.

Results

Our data from 68 men, 95 women of mean age 59.8 years were summarized in **Table 1**. One hundred six patients (65%) had type A anatomy or conventional patterns of intrahepatic duct anatomy, in which the right posterior duct fused the right anterior duct to form the right hepatic duct. Then, the right hepatic duct formed a junction with the left hepatic duct to form the common hepatic duct as shown in **Figure 2**.

Variations from conventional pattern were seen in 57 patients. The most common variant was trifurcation (type B anatomy) or triple confluence of right anterior duct, right posterior duct, and left hepatic duct. The trifurcation type occurred in 28 patients (17.2%) as shown in **Figures 3** and **4**.

Type C anatomy or right posterior duct (RP) joining the common hepatic duct (RA and LHD joining to form the common trunk and RP joining distally) occurred in nine patients (5.5%) as shown in **Figure 5**.

Drainage of the right posterior duct into the left hepatic duct before its confluence with the right anterior duct or type D anatomy was found in 15 patients (9.2%) can be seen in **Figure 6**.

The remaining five patients (3.1%) were classified as other variations, one exhibiting anomalous drainage of right posterior duct to common bile duct (**Figure 7**) and four showed accessory hepatic ducts (**Figure 8**).

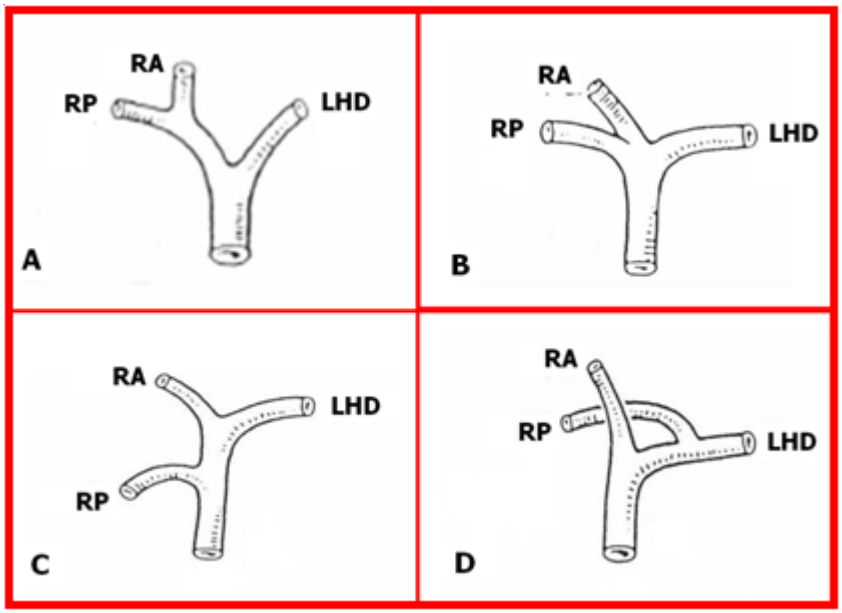

Figure 1. Common normal variants of the confluence of hepatic biliary tributaries (RA=right anterior duct, RP=right posterior duct, LHD=left hepatic duct)

Table 1. Patterns of intrahepatic bile duct observed at MRCP

Type	Intrahepatic bile duct variant	Patients	
		Number	%
A	Conventional pattern	106	65
B	Trifurcation	28	17.2
C	Drainage of RP to CHD	9	5.5
D	Drainage of RP to LHD	15	9.2
Other	Accessory duct, drainage of RP to common bile duct	5	3.1

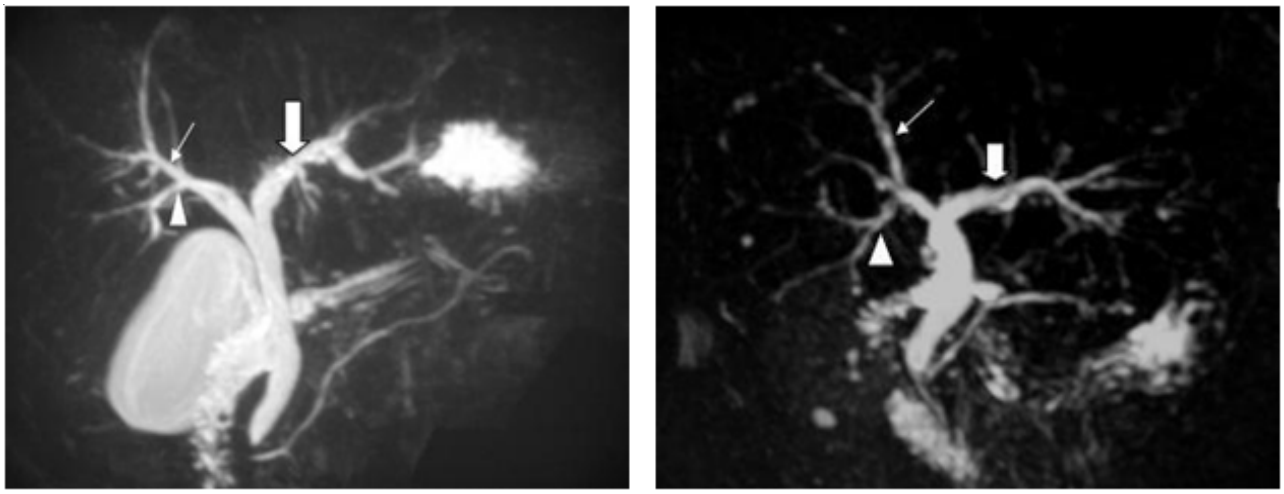

Figure 2. Conventional pattern of hepatic ductal anatomy in two patients **A:** a 43-year-old man with hepatitis B and HIV infection. MRCP shows normal confluence of right posterior duct (arrowhead) and right anterior duct (small arrow) to form right hepatic duct. Right hepatic duct fused left hepatic duct (large arrow) to form common hepatic duct. **B:** a 72-year-old woman with mild intrahepatic bile duct dilatation in check-up ultrasound. The right hepatic duct is formed by fusion of the right anterior duct (small arrow) and right posterior duct (arrowhead). The common hepatic duct is formed by fusion of the right hepatic duct and the left hepatic duct (large arrow).

Figure 3. Trifurcation (type B). MRCP in 78-year-old man shows simultaneous emptying of the right posterior duct (arrowhead), right anterior duct (small arrow), and left hepatic duct (large arrow) into the common hepatic duct.

Figure 4. Common biliary variant in 69-year-old woman with rising of CEA level and showing mild intrahepatic bile duct and CBD dilatation in CT study. She was sent to MRCP study for further evaluation. MRCP shows trifurcation or triple confluence of right anterior duct (small arrow), right posterior duct (arrowhead), and left hepatic duct (large arrow).

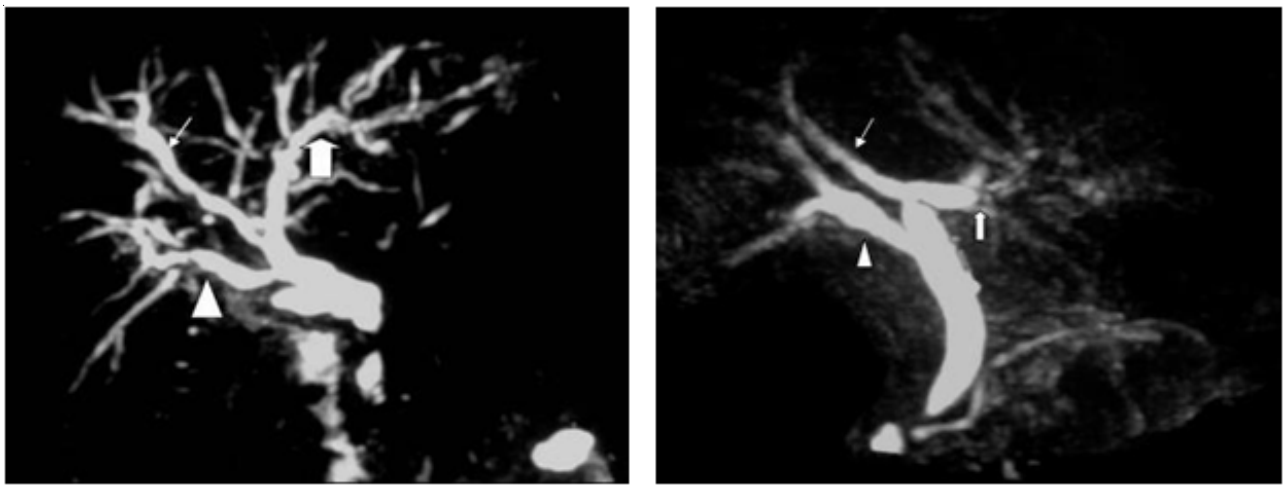

Figure 5. MRCP in two patients **A:** a 72-year-old man with CBD stricture shows drainage of the right posterior duct (arrowhead) into the common hepatic duct. **B:** a 38-year-old man with abdominal pain. He was sent to MRCP study for excluding biliary stone. The MRCP shows drainage of the right posterior duct (arrowhead) into the common hepatic duct, small arrow=right anterior duct, large arrow=left hepatic duct.

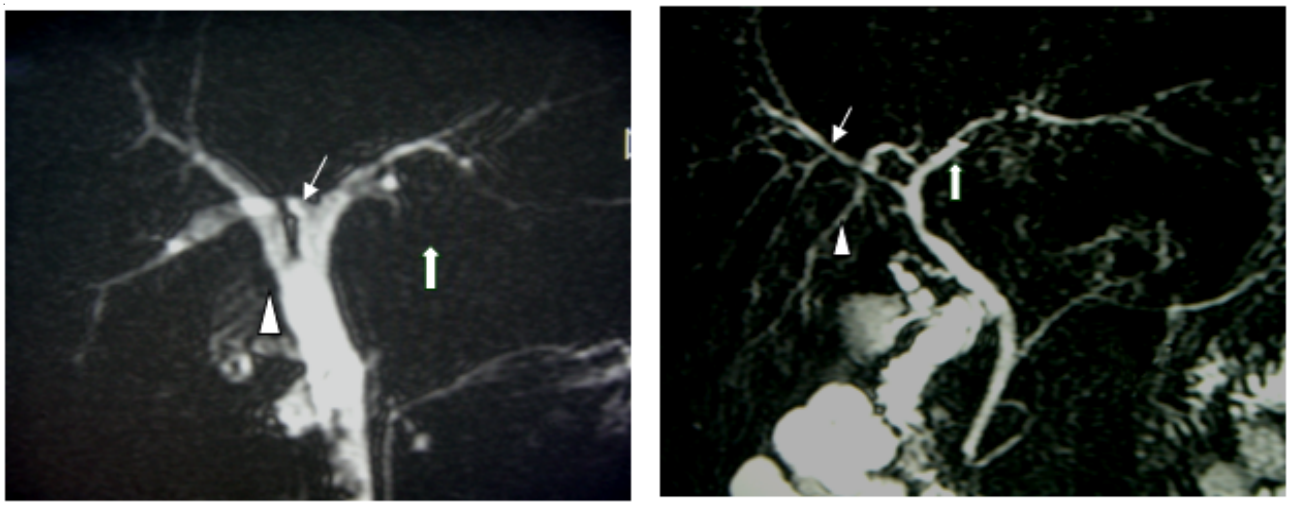

Figure 6. MRCP in two patients **A:** a 67-year-old man with chronic abdominal pain **B:** a 54-year-old man. The arrowheads show drainage of the right posterior duct into the left hepatic duct (large arrow), small arrow=right anterior duct.

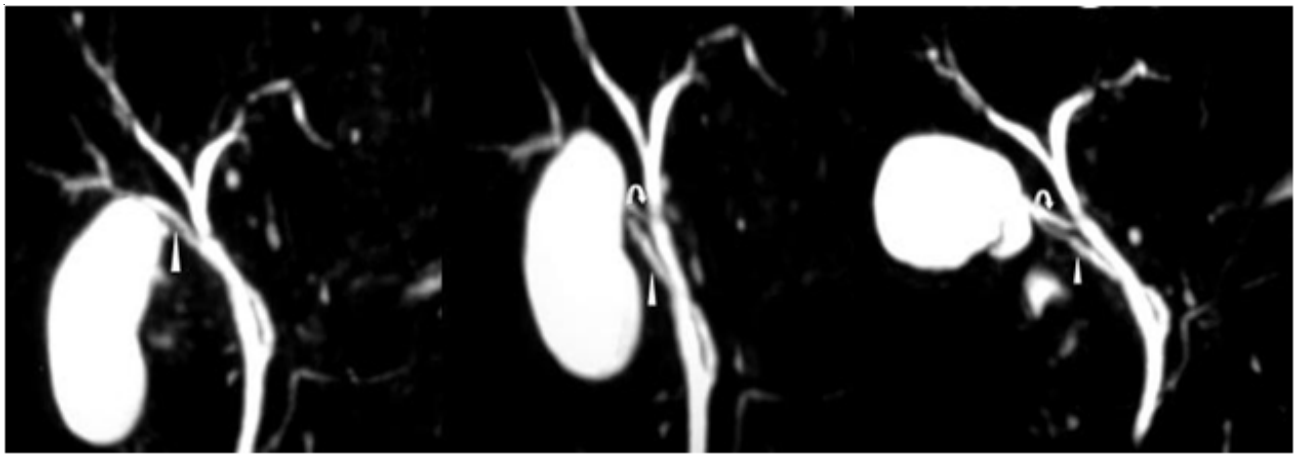

Figure 7. MRCP shows anomalous drainage of right posterior duct (arrowhead) to common bile duct. Curve arrow=cystic duct.

Figure 8. MRCP shows two patients (**A** and **B**) with accessory hepatic ducts (arrows).

Discussion

Variations in anatomy of intrahepatic bile ducts have long been recognized. In the advent of minimally invasive therapeutic intervention for bile duct, hepatic resection, or partial liver transplantation, accurate knowledge of anatomy of intrahepatic bile ducts is critical.

Choi et al. [19] published a larger series of 300 consecutive donors for liver transplantation who underwent intraoperative cholangiography. In their series, conventional intrahepatic biliary anatomy was detected in 63% of cases (n=188). Twenty-nine patients (10%) had trifurcation or triple confluence. Drainage of the right posterior duct into the left hepatic duct was seen in 11% (n=34) and anomalous drainage of the right posterior duct into the common hepatic duct was found in 6% (n=19).

Another researcher, Cheng et al. [14], evaluated 210 cholangiograms, showing conventional patterns in 65.7%, trifurcation in 16.7% and RP drainage to LHD in 14%.

We arbitrarily classified branching pattern of intrahepatic ducts based on the relationships between the hepatic segmental ducts. Our results showed that in the majority of the subjects (65%), the anatomy of the intrahepatic bile ducts was type A, or the conventional pattern, a finding similar to earlier studies.

Among several types of anatomic variant, type B or trifurcation was the most common (17.2% of subjects). This finding is consistent with previous studies [14, 20]. Drainage of the right posterior duct into the left hepatic duct before its confluence with the right anterior duct or type D was found in 6-18% of the population [16-23]. Our study showed 9.2% of this variation. Knowledge of this anatomic variation is important, especially when performing a left hepatectomy, it is crucial to recognize an aberrant drainage of the right posterior duct into the left hepatic duct, because ligation of these ducts will produce biliary cirrhosis of segments VI and VII, or segments V and VIII, respectively [16].

Moreover, in biliary disease such as hepatolithiasis, the ramification pattern of intrahepatic duct may affect hepatic biliary flow, leading to biliary stasis and subsequent secondary bacterial infection and recurrent pyogenic cholangitis. Kim et al [18] proposed that the left hepatic duct joins the common hepatic duct at a more acute angle than the right hepatic duct, and because the acute angle created between the right posterior duct and the left hepatic duct in type D, such a patient is, in theory, likely to experience more biliary stasis and a greater incidence of hepatic stone than those with other types.

Aberrant right posterior duct draining into the common hepatic duct was found in 5.5% in this study and is consistent with previous studies [17-20, 22, 23]. Although the overall incidence of bile duct injury after laparoscopic cholecystectomy is usually less than 1%, anatomic factors represent one of the major causes of bile duct injuries. Presence of an aberrant right posterior duct draining into the common hepatic duct or into the common bile duct may disorient the surgeon, causing inadvertent ligation or section of the aberrant ducts [7].

Accessory hepatic ducts have been reported in approximately 2% of the population and may originate from either the right or left ductal system, along which they run. They may present as a solitary finding or in conjunction with other types of intrahepatic duct variation [7]. In our study, accessory hepatic ducts were observed in four patients (2.5%). Although accessory ducts are a minor aspect of variation, they should not be overlooked in liver transplantation or hepatic resection. Identification of accessory ducts is important if serious complications such as biloma or bile leakage are to be avoided. Because electrocautery may seal an accessory duct temporarily, even with careful inspection of the cut margin of the liver, an awareness of possible variation in an accessory duct is important [19].

In this study, there is some degree of selection bias. The MRCP studies were selected from patients with suspected biliary or pancreatic disease. A major limitation of our study was the fact that the biliary configurations were not confirmed at cholangiography or surgery.

In conclusion, atypical branching patterns of intrahepatic bile ducts were found in 35% of cases. The most common variation was trifurcation (17.2%). Variant intrahepatic bile duct anatomy is relevant to the practice of safe and efficacious surgical and other hepatobiliary intervention. A preoperative understanding of bile duct variation will help avoid possible complications and help achieve the most effective relief of biliary obstruction.

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