Six Rare Biliary Tract Anatomic Variations: Implications for Liver Surgery

Altı Nadir Safra Yolları Anatomik Varyasyonu: Karaciğer Cerrahisi Sonuçları

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Abstract

Objective: The variations in the anatomy of the biliary tract need to be recognized in modern liver surgery. The purpose of this clinical and anatomical study is to describe several novel biliary tract variations and to outline their practical importance for liver resections and transplantations.

Materials and Methods: Over the previous 10 years, the anatomic variations of the bile ducts were examined during 600 intraoperative cholangiographies, 104 segmentectomies and 54 hemihepatectomies in patients with liver diseases. The intraoperative anatomies of the right and left hepatic ducts and the common hepatic duct confluence were analyzed.

Results: Twenty-two variations occurred in 59.5% of the patients. Six variations were described for the first time: an accessory right hepatic duct in which a cystic duct drained; a tetrafurcation from the right anterior hepatic duct, right posterior hepatic duct and bile ducts for Segments 2 and 3 with aberrant bile drainage from Segment 4 into the bile duct for Segment 8; an aberrant bile drainage from Segments 6 and 7 into the common hepatic duct; an accessory bile duct for Segment 6 that drained into the bile duct for Segment 3; a tetrafurcation from the right anterior hepatic duct and the bile ducts for Segments 6, 3 and 2 with bile from Segment 7 draining into the bile duct for Segment 2; and an accessory bile duct for the left hemiliver that drained bile from the Type 4 small accessory hepatic lobe (according to Caygill & Gatenby) into the common hepatic duct.

Conclusion: These newly described biliary tract variations should be recognized by liver surgeons to avoid unwanted postoperative complications.

Key Words: Bile ducts, Biliary tract variations, Cholangiography, Hepatectomy, Liver segments

Özet

Amaç: Safra yolları anatomisi içinde farklılıkların, modern karaciğer cerrahisinde tanınması gereklidir. Bu klinik ve anatomik çalışmanın amacı, birkaç yeni safra yolları değişiminin tanımlanması ve karaciğer rezeksiyonları ve nakli için pratik öneminin altını çizmektir.

Gereç ve Yöntem: Bundan önceki on yılda, safra kanallarının anatomik varyasyonu karaciğer hastalığı olanlarda 600 intraoperatif kolanjiografi, 104 segmentektomi ve 54 hemihepatektomi incelendi. Sağ ve sol hepatik kanalların intraoperatif anatomileri ve ortak hepatik kanal kavşakları analiz edildi.

Bulgular: Hastaların %59.5’inde iki kanal varyasyonu gözlemlemiş. Altı varyasyon ilk kez taraflı edilmiştir: bir sistik kanalı drene olan bir aksesuar sağ hepatik kanal; Segment 4 anomale safra drenajı ile 2 ve 3 segmentleri için sağ anterior hepatik kanal, sağ posterior hepatik kanal ve safra yolları bir tetrafurksiyon içine segment 8 safra kanalı; segment 6 ve 7’den ortak hepatik kanal içine bir anomale safra drenajı; segment 3 safra kanalı içine drene olan segment 6 için bir aksesuar safra kanalı, sağ anterior hepatik kanal bir tetrafurksiyon ve safra segmentleri 6, 3 ve segment 2 safra kanalına drene segment 7 ile 2 safra kanalları ve sol hemiliver için bir aksesuar safra kanalına drene safra bu Tip 4 küçük aksesuar karaciğer lobu (Caygill & Gatenby’a göre) içine ortak hepatik kanal.

Sonuç: Bu yeni tanımlanan safra yolları varyasyonları istenmeyen ameliatiyon sonrası komplikasyonları önlemek için karaciğer cerrahları tarafından göz önünde bulundurulmalıdır.

Anahtar Kelimeler: Hepatektomi, Karaciğer segmenti, Kolanjiyografi, Safra yolları varyasyonları

Introduction

Smajda and Blumgart’s classification [1] of the biliary tract anatomic variations is the most commonly used classification in contemporary liver surgery [2]. This classification includes six main anatomic types. Recently, more modern and comprehensive biliary tract classifications were suggested [3]. Numerous bile duct anatomic variations have been encountered in 50% of the population [1, 4]. The anatomic variations of the right hepatic duct (RHD), the left hepatic duct (LHD) and the common hepatic duct (CHD) have been extensively studied, whereas little is known about the
details of the bile drainage of Segment 4 (Sg4) [2, 5-7]. Sg3 bile drainage has been described as well [8]. A detailed analysis of Sg4 bile drainage has depicted three main types and ten derivative anatomic variations [9]. However, the number of bile duct variations is consistently increasing, and therefore, sufficient knowledge of these variations is important for performing liver resections and transplantations.

Our objective was to present several newly detected variations of the biliary tract and to outline the practical importance of their recognition by liver surgeons.

**Materials and Methods**

The examinations of the biliary tract anatomic variations were based on 600 intraoperative cholangiographies, 104 segmentectomies and 54 hemihepatectomies performed in patients with liver diseases who were hospitalized in the Department of Surgery, Naval Hospital of Varna, Bulgaria between January 1, 2001 and December 31, 2010. We focused on the intraoperative anatomy of the RHD, LHD and CHDC.

**Results**

We observed 32 biliary tract anatomic variations, whereas more than 50 have already been reported in other studies. The incidence rate of these variations reached 59.5% of our cases. We described the following six variations with incidence rates below 0.2% for the first time (Figure 1): an accessory RHD in which a cystic duct (CD) drained (Figure 2) [10]; a tetrafurcation from the anterior RHD (RAHD), posterior RHD (RPHD), and the bile ducts for Sg2 and Sg3 with aberrant bile drainage from Sg4 into the duct for Sg8 (Figure 3a) [11]; an aberrant bile drainage from Sg6 and Sg7 into the CHD (Figure 3b) [11]; an accessory bile duct for Sg6 that drained into the bile duct for Sg3 (Figure 4a); a tetrafurcation from the RAHD with bile ducts for Sg6, Sg3 and Sg2 with Sg7 draining into the bile duct for Sg2 (Figure 4b); and an accessory bile duct for the left hemiliver that drained bile from the Type 4 small...
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**Discussion**

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**RHD features**

The RHD is formed through merging of the bile ducts for the right anterior and posterior sectors because the duct for the right posterior sector is epiportal. This variation is considered ‘typical’ by most authors and occurs in 57-77.5% of cases [2-7, 13-18].

Anatomical variations of the RHD differing from the ‘typical’ variations were observed in 27.8% of our cases (n=166), whereas the frequency reported in the literature was 22.5-43% [2-6, 13-15,18]. The bile duct for the right posterior sector ran hypoportally in 16.5% of our cases (n=99), which has been shown in 2.5-13% of cases in other studies [2, 4]. Solitary bile ducts for the right anterior and posterior sectors were absent in 4.3% of our cases (n=26). In these cases, the ducts for Sg5, Sg6, Sg7 and Sg8 drained independently into the RHD. This anatomic variation occurred in 2.5% of the cases in previous studies [2]. The danger of cessation of the bile ducts of the intact right segments during right mono-, bi- and...
multisegmentectomies is not commonly considered. There was no solitary bile duct for the right anterior sector in 4.3% of our cases (n=26). The bile ducts for Sg5 and Sg8 drained separately into the RHD in 10-20% of cases in previous studies [2, 3]. The practical significance of this anatomic aberration is the danger of interruption of the bile duct for the right posterior sector during a monosegmentectomy or during a right anterior sectionectomy.

There was an accessory RHD in 0.3% of our patients (n=2), which exited from the porta hepatis and entered the CHD. In one case, the CD drained into it. No previous studies have reported this variation. Because of its proximity to the cystohepatic angle formed by the CD and the gallbladder below, the right hepatic lobe above, and the CHD medially, this accessory duct may be accidentally transected or ligated during cholecystectomy, and therefore, complications, such as the formation of a biliary fistula, biloma, sepsis, pain and repetitive episodes of cholangitis, may occur [19]. If a large volume of parenchyma is drained by the ligated duct, biliary atrophy with resultant jaundice may occur. An accessory bile duct for Sg6, which drains into the bile duct for Sg3, was observed for the first time in this study (n=1). The presence of this variation may increase the risk of partial transection of the bile drainage from Sg6 and cholestatic enzyme elevation during a left hepatectomy, left lateral sectionectomy or independent segmentectomy. A separate bile drainage from Sg6 and Sg7 into the CHD was observed in this study for the first time as well (n=1). There is a potential risk of interruption of these two bile ducts during a cholecystectomy and CHD resection. An aberrant bile drainage from Sg7 into the bile duct for Sg2 was also observed and has not been previously reported (n=1). The presence of this variation increases the risk of potential cessation of the bile drainage from Sg7 and cholestatic enzyme elevation in left hepatectomies, left lateral sectionectomies and monosegmentectomies.

**CHDC features**

The CHDC was formed from the RHD and LHD in 66.3% of our cases (n=398) and in up to 57% of cases reported elsewhere [1, 6, 13]. There was a triple confluence in 11.8% of our cases (n=71) and between 5% [3, 5, 20] and 16% of patients in other studies [1]. Usually, this confluence was formed from the LHD and the bile ducts for the right anterior and posterior sectors and occurred in 3.5% of our cases (n=21), whereas its frequency ranged from 5-12% in previous studies [1, 3, 6, 15]. During a left hepatectomy, there is an increased risk of damage to the bile drainage of the right segments because of this variation. The bile duct for the right posterior sector drained into the LHD in 14.3% of our cases (n=86), which was the second highest frequency observed in our study, and in 5-19% of cases in previous studies [3-6, 14]. This alteration can cause biliary stasis and relapsing cholangitis [4]. As a result of this variation, the bile drainage from Sg6 and Sg7 can be interrupted during a left hepatectomy, mesohepatectomy, bisegmentectomy 1,4, left trisectionectomy and sometimes during a left lateral sectionectomy. We observed an aberrant bile drainage of the right anterior sector into the LHD in 2% of our cases (n=12) and in 1% of cases in previous studies [2, 3, 6, 13, 16]. The presence of this alteration may increase the risk of cessation of the bile drainage for Sg5 and Sg8 during a left hepatectomy and bisegmentectomy 1,4. Bile drained abnormally from the right posterior sector into the CHD or the CD in 0.83% of our patients (n=5) and in 4.5-16% of cases in previous studies [1-4, 6, 13, 21]. The risk of interruption of the bile drainage from Sg6 and Sg7 during CHD.
resection or after a cholecystectomy in patients with this alteration may be increased. We detected three variations of a four-fold confluence without a solitary LDH in 1.6% of our patients (n=6). For the first variation, this confluence was formed by merging of the bile ducts for the right posterior and anterior sectors, Sg2 and Sg3: the second variation was formed by merging of the RHD and the bile ducts for Sg4, Sg3, and Sg2; and the third variation was formed by merging of the bile ducts for the right posterior and anterior sectors, Sg2 and Sg3, and the bile from Sg4 drained into the bile duct for Sg8. The third variation has not been previously reported in the available literature.

Although there were previously reported anatomic variations that were not observed in our study group, these variations are extraordinarily rare and involve the presence of aberrant or accessory bile ducts or the absence of a confluence. The existing ‘cysticchoepatic duct’ is essential when performing a laparoscopic cholecystectomy. In 3% of previous cases, the duct for the right posterior sector or the whole RHD drained into the CD [15]. We failed to detect this variation in our study or when performing more than 1000 laparoscopic cholecystectomies. The RHD joined the CHD below the normal confluence in up to 25% of cases in a previous study (9% anterior and 16% posterior) [20] to form a self-confluence (“convergence étagée”) [2]. Accessory bile ducts occurred in 2-10% of cases in previous studies [2, 15] and drain small portions of the liver. If unnoticed, these ducts could cause postoperative bilirrhagia during a parenchymal transection [22].

LHD features

The anatomic variations of the biliary tract for the left hemiliver were primarily associated with the number and localization of the bile ducts for Sg4. Intrahepatically, all of the bile ducts except for Sg4 are covered by Glisson’s capsule [23]. Sg4 was often solitary and drained centrally into the LHD. This variation is usually considered to be typical with a frequency of 15.6-82% in previous studies [1, 9, 13, 24-27], whereas it occurred in 41.5% of our cases (n=249). In the remaining 58.5% of our cases, 8 anatomic variations were observed. In 64.3% of our cases, the bile duct for Sg4 drained centrally, but in 38.6% of our cases, it drained peripherally. In the remaining 5% of our cases, there was mixed drainage. In the presence of central drainage, preservation of the bile duct confluence for Sg2 and Sg3 is important in split-liver transplantation involving hepatic division into two parts along the fissure umbilicales. The difficulty of this procedure is lowered if the confluence is located to the left or behind this particular attachment site.

The bile drainage of Sg1 varies considerably. The number of bile ducts for Sg1 ranges between one and six [2-4, 18, 28]. There were two bile ducts in 80% of cases in previous studies [2, 5] and in 66.6% of our cases. Depending on the size and localization of the caudate lobe, these ducts drain into the CHDC, LHD, or RHD. The bile ducts for proc. caudatus and Spiegel’s lobe merge into one duct and drain into the CHDC in 26% of the population [18] and in 33.5% (n=201) of our cases.

In conclusion, detailed knowledge of biliary tract anatomic variations is important for safe and effective liver resection surgery and transplantation. Currently, the frequency of these variations is difficult to estimate. There is no original report in the literature that describes all of the variations that have been observed worldwide. Our study contributes six newly described biliary tract anatomic variations to the literature; however, the occurrence rates and optimal surgical management techniques for these variations remains open for future interdisciplinary research.

Conflict of interest statement: The authors declare that they have no conflict of interest to the publication of this article.

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