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# Radiologic evaluation of vasculobiliary anatomy in the umbilical fissure

*Gu-wei Ji, MD,*[a] *Fei-peng Zhu, MD,*[b] *Ke Wang, MD,*[a] *Yong-xiang Xia, MD,*[a] *Chen-yu Jiao, MD,*[a] *Zi-cheng Shao, MD,*[a] *and Xiang-cheng Li, MD*[a,*]

[a] *Key Laboratory on Living Donor Liver Transplantation, Department of liver surgery, Ministry of Health, First Affiliated Hospital of Nanjing Medical University, Nanjing, P.R. China*

[b] *Department of Radiology, First Affiliated Hospital of Nanjing Medical University, Nanjing, P.R. China*

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ABSTRACT

*Background:* Preoperative evaluation of vasculobiliary anatomy in the umbilical fissure (U-point) is pivotal for perihilar cholangiocarcinoma (PCCA) applied to right-sided hepatectomy. The purpose of our study was to review the vasculobiliary anatomy in the U-point using three-dimensional (3D) reconstruction technique, to investigate the diagnostic ability of 2D scans to evaluate anatomic variations, and to discuss its surgical implications.

*Methods:* A retrospective study of 159 patients with Bismuth type I, II, and IIIa PCCA, who received surgery at our institution from November 2012 to September 2016, was conducted. Anatomic structures were assessed using multidetector computed tomography (MDCT) by one hepatobiliary surgeon, whereas 3D images were reconstructed by an independent radiologist. Normal confluence pattern of left biliary system was defined as the left medial segmental bile duct (B4) joining the common trunk of segment II (B2) and segment III (B3) ducts, whereas aberrant confluence patterns were classified into 3 types: type I, triple confluence of B2, B3, and B4; type II, B2 draining into the common trunk of B3 and B4; type III, other patterns. Surgical anatomy of B4 was classified into the central, peripheral, and combined type according to its relation to the hepatic confluence. The lengths from the bile duct branch of Spiegel's lobe (B1l) to the orifice of B4 and the junction of B2 and B3 were measured on 3D images. The anatomy of left hepatic artery (LHA) was classified according to different origins and the spatial relationship related to the U-point.

*Results:* 3D reconstruction revealed that normal confluence pattern of left biliary system was observed in 71.1% (113/159) of all patients, and variant patterns were type I in 11.9% (19/159), type II in 12.6% (20/159), and type III in 4.4% (7/159). The length from B1l to the junction of B2 and B3 was 12.1 ± 3.1 mm in type I variation, which was significantly shorter than that in normal configuration (30.0 ± 6.8 mm, $P < 0.001$) but significantly longer than that in type II variation (9.6 ± 3.4 mm, $P = 0.019$). Surgical anatomy of B4: the peripheral type was most commonly seen (74.2%, 118/159), followed by central type (15.7%, 25/159) and combined type (10.1%, 16/159). The distance between the B1l and B4 was 8.4 ± 2.4 mm in central and combined type, which was significantly shorter than that in peripheral type (14.5 ± 4.1 mm, $P < 0.001$). A replaced or accessory LHA from the left gastric artery was present in 6 (3.8%) and 9 (5.7%) patients, respectively. LHA running along the left caudal position of U-point was present in 143 cases (89.9%), along the right cranial position of

* *Corresponding author.* Key Laboratory on Living Donor Liver Transplantation, Department of liver surgery, Ministry of Health, First Affiliated Hospital of Nanjing Medical University, 300 Guangzhou Road, Nanjing 210029, P.R. China. Tel.: +86 18951999088; fax: +86 68136450.

E-mail address: drxcli@njmu.edu.cn (X.-c. Li).



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U-point in nine cases (5.7 %), and combined position in seven cases (4.4%). Interobserver agreement of two imaging modalities was almost perfect in biliary confluence pattern (kappa = 0.90; 95% confidence interval: 0.79-1.00), substantial in surgical anatomy of B4 (kappa = 0.74; 95% confidence interval: 0.62-0.86), and perfect in LHA (kappa = 1.00).
*Conclusions:* Thoroughly understanding the imaging characters of surgical anatomy in the U-point may be benefit for preoperative evaluation of PCCA by successive review of 2D images alone, whereas 3D reconstruction technique allows detailed hepatic anatomy and individualized surgical planning for advanced cases.


## Introduction

Cholangiocarcinoma is a devastating biliary malignancy and distinctly classified into three subsets according to the anatomic location: intrahepatic, perihilar, and distal cholangiocarcinoma.[1-3] Generally, the cystic duct is the anatomic demarcation between perihilar and distal bile duct. However, the border between perihilar and intrahepatic bile duct is defined by utilizing the portal system according to the concept of "limits of ductal dissection".[4-7] Specifically, the left and right proximal border of perihilar bile duct is located topologically at the right side of the umbilical fissure (U-point) and the left side of the bifurcation of the right anterior and posterior portal branches, respectively.[8]

Perihilar cholangiocarcinoma (PCCA) is the most prevalent subset, accounting for 50% of all cholangiocarcinomas, and curative resection remains the only possibility for cure.[1,3,9] Combined right-sided hepatectomy is the advocated surgical procedure and most likely enables the accomplishment of *en bloc* resection for the anatomic considerations as follows: longer resectable extrahepatic bile duct on the left and right hepatic artery running in the close vicinity to the common hepatic duct.[10] Therefore, thoroughly understanding the surgical anatomy in the remnant is pivotal for appraisal of the resectability and safe hepatic resection. However, variable vasculobiliary structures and multidimensional tumor invasion contribute to the technical challenge of preoperative evaluation and surgical management.

Fortunately, recent progress in radiologic techniques and digital medical devices has significantly improved the quality of multidetector computed tomography (MDCT) images, whereas three-dimensional (3D) reconstruction system allows spatially accurate depiction of hepatic anatomy and has been widely used for preoperative planning in hepatobiliary surgery.[4-6] Notably, 3D rendering is manually reconstructed from the available image data, whereas the reconstruction system offers real-time comparison of 3D model and two-dimensional (2D) images in multiple planes, which may be potentially favorable for obtaining a better stereotactic understanding of hepatic anatomy on 2D images.[11]

As the umbilical portion of the left portal vein is a relative steady reference, the purpose of our study was to review the vasculobiliary anatomy in the U-point using 3D reconstruction technique, to investigate the diagnostic ability of 2D scans to evaluate anatomic variations, and to discuss its surgical implications for PCCA applied to right-sided hepatectomy.

## Materials and methods

### *Patients*

From November 2012 to September 2016, 162 consecutive patients with radiological Bismuth type I, II, and IIIa PCCA received exploratory laparotomy at the First Affiliated Hospital of Nanjing Medical University. Three patients were excluded from the initial investigation for lacking of high definition images. Therefore, a total of 159 patients (101 men and 58 women) with an average age of 61 ± 11 y (range: 38-85 y) were enrolled in this radiological study, comprising of 11 patients with Bismuth type I tumor, 15 patients with Bismuth type II tumor, and 133 patients with Bismuth type IIIa tumor. This study was approved by the ethics committee of First Affiliated Hospital of Nanjing Medical University, and written informed consent was obtained from all patients.

### *Imaging technique and evaluation*

All patients underwent triple-phase MDCT examination prior to biliary drainage, which consisted of plain scan, arterial phase, and portal venous phase. For precontrast imaging, 5-mm-thick sections were obtained. With a power injector, 120 mL of nonionic contrast material (Ioversol 320; Jiangsu Hengrui Medicine, China) was injected at a rate of 3.0-4.0 mL/s. Arterial phase and portal venous phase scanning were initiated with 20- to 25-s and 50- to 60-s delay, respectively. The reconstruction parameters were 1.5-mm slice thickness with 1.5-mm intervals for contrast-enhanced images.

MDCT data were imported into the medical reconstruction system (IQQA-Liver, EDDA technology Inc, Princeton, NJ) for building spatially accurate 3D models. All vasculature was reconstructed manually by an abdominal radiologist. Alternatively, MDCT images were reviewed systematically from the cranial to the caudal side by a hepatobiliary surgeon, who was experienced in 3D reconstruction and preoperative evaluation of resectability of PCCA, to classify biliary vascular configuration into various types as listed below. They were blind to each other, and other relevant clinical and pathologic data.

### *Anatomic definition and classification*

Normal confluence pattern of left biliary system was defined as the left medial segmental bile duct (B4) joining the common trunk of segment II (B2) and segment III (B3) ducts. Aberrant confluence patterns were classified into the following three types according to the anatomic features: type I, triple