Successful Parenchyma-Sparing Anatomical Surgery by 3-Dimensional Reconstruction of Hilar Cholangiocarcinoma Combined with Anatomic Variation

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ABSTRACT
The combination of hilar cholangiocarcinoma and anatomic variation constitutes a rare and complicated condition. Precise understanding of 3-dimensional position of tumor in the intrahepatic structure in such cases is important for operation planning and navigation. We report a case of a 61-year woman presenting with hilar cholangiocarcinoma. Anatomic variation and tumor location were well depicted on preoperative multidetector computed tomography (MDCT) combined with 3-dimensional reconstruction as the right posterior segmental duct drained to left hepatic duct. The common hepatic duct, biliary confluence, right anterior segmental duct, and right anterior branch of portal vein were involved by the tumor (Bismuth IIIa). After carefully operation planning, we successfully performed a radical parenchyma-sparing anatomical surgery of hilar cholangiocarcinoma: Liver segmentectomy (segments 5 and 8) and caudate lobectomy. MDCT combined with 3-dimensional reconstruction is a reliable non-invasive modality for preoperative evaluation of hilar cholangiocarcinoma.

Key Words: Hilar cholangiocarcinoma. Multidetector computed tomography (MDCT). 3-dimensional reconstruction. Anatomic variation.

INTRODUCTION
Hilar cholangiocarcinoma, occurring at the confluence of the left and right hepatic bile ducts, is the most common cancer of extrahepatic ductal system.1 Complete resection is the most effective and the only potential curable treatment for hilar cholangiocarcinoma. However, due to the complex structure of hilus hepatis, postoperative morbidity and mortality rates remain high.2 Successful operation planning and navigation systems in liver surgery can provide 360 degree imaging of hilar structure including bile duct, hepatic artery, and portal vein so that every pitfall such as rare anatomic variation can be detected preoperatively.3 Simultaneously, liver parenchyma can be preserved to the highest degree on the basis of R0 resection by precise preoperative evaluation.

Here, we report a case of a 61-year woman presenting with hilar cholangiocarcinoma, to describe the value of multidetector computed tomography (MDCT) combined with 3-dimensional reconstruction in preoperative evaluation and surgical planning of hepatobiliary surgery.

CASE REPORT
A 61-year woman presented with right upper abdominal pain and jaundice for one week. Laboratory findings, including liver function and tumor marker, revealed that total bilirubin, alanine aminotransferase and carbohydrate antigen 19-9 were elevated (Table I). Contrast-enhanced MDCT (LightSpeed VCT, GE Healthcare, Milwaukee, WI, USA) indicated a 1.2 x 1.0 cm soft-tissue mass at the hepatic hilum with upstream ductal dilatation (Figure 1). Anatomic variation was found in this case after 3-dimensional reconstruction, using a quantitative imaging analysis system (IQQA-Liver, EDDA Technology Inc., Princeton, NJ, USA). The right posterior segmental duct (RPSD) ran beneath the portal vein and drained into the left hepatic duct (LHD). In addition, the right hepatic artery originated from the superior mesenteric artery and the right anterior branch of portal vein originated from the left branch of portal vein (Figure 2). The common hepatic duct, biliary confluence, right anterior segmental duct (RASD), and

<table>
<thead>
<tr>
<th>Inspection items</th>
<th>Results</th>
<th>Normal levels</th>
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</thead>
<tbody>
<tr>
<td>Total bilirubin</td>
<td>120.20 µmol/L</td>
<td>&lt;17.1 µmol/L</td>
</tr>
<tr>
<td>Direct bilirubin</td>
<td>90.10 µmol/L</td>
<td>&lt;5.0 µmol/L</td>
</tr>
<tr>
<td>Alanine aminotransferase</td>
<td>327 U/L</td>
<td>&lt;75 U/L</td>
</tr>
<tr>
<td>Aspartate aminotransferase</td>
<td>257 U/L</td>
<td>&lt;40 U/L</td>
</tr>
<tr>
<td>Carbohydrate antigen 19-9</td>
<td>555.9 U/ml</td>
<td>&lt;35 U/ml</td>
</tr>
<tr>
<td>a-fetoprotein</td>
<td>1.90 ng/ml</td>
<td>&lt;5 ng/ml</td>
</tr>
</tbody>
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Table I: Laboratory findings.
right anterior branch of portal vein were involved by the tumor (Bismuth IIIa) and planned to be resected combined with liver segment 5, segment 8, and caudate lobe to achieve R0 resection. The RPSD was not involved by the tumor and planned to be reserved combined with liver segment 6 and segment 7. The estimated future liver remnant (FLR) after right hemihepatectomy with caudate lobectomy was 38% of the total liver volume while the FLR, after parenchyma-sparing anatomical liver resection, was 70%. Percutaneous transhepatic cholangiography (PTC), endoscopic retrograde cholangiopancreatography (ERCP), and portal vein embolization were not performed.

The patient underwent a radical parenchyma-sparing anatomical surgery of hilar cholangiocarcinoma with liver segmentectomy (segments 5 and 8) and caudate lobectomy as preoperatively planned (Figure 3). Cavitron ultrasonic surgical aspirator was used for liver resection and high-frequency electrocautery was used for hemostasis. Lymphadenectomy and Roux-en-Y hepaticojejunostomy were also performed. The pathological result was poorly differentiated adenocarcinoma without lymph node metastasis and the resection margins were negative microscopically. The patient was well-recovered and followed up for one year and showed no recurrence or metastasis by MDCT.

**DISCUSSION**

Surgery of hilar cholangiocarcinoma remains one of the most challenging operations for surgeons. Radiological assessment includes tumor extent, vascular involvement and distant metastasis. It is very important in hepatobiliary pancreatic surgery. Comprehensive and accurate assessment can guide the surgery and minimize the loss of normal liver tissue. The combination of tumor and anatomic variation constitutes a rare and complicated condition. Preoperative evaluation of resectability and comprehensive understanding of biliary and vascular anatomy at the hepatic hilum is crucial. PTC or ERCP is frequently performed to show biliary anatomy and location of biliary obstruction. But it is invasive and may cause many severe complications, such as cholangitis and bleeding. MDCT combined with 3-dimensional reconstruction can make a valuable contribution to our understanding of the anatomy without invasiveness and complication. The longitudinal extension of tumor and vascular involvement can be evaluated accurately by MDCT to achieve R0 resection, and the performance is similar to that of PTC and magnetic resonance imaging (MRI).
In this case, 3-dimensional reconstruction images clearly visualized that the RASD and right anterior branch of portal vein were involved by tumor with the RPSD draining into the LHD; the right hepatic artery originating from the superior mesenteric artery, and the right anterior branch of portal vein originating from the left branch of portal vein. These images were 3-dimensional and could be rotated and observed at any angle, so they were more accurate and easier to be understood than 2-dimensional images of PTC or magnetic resonance cholangiopancreatography (MRCP). The deviation of spatial structure reconstructed by 2-dimensional CT images in surgeon’s mind could also be avoided. The preoperative information of 3-dimensional reconstruction images could improve R0 resection rate, reduce risk of bile duct and vascular injury, and lead to less blood loss. In addition, it could indicate bile duct orifices in the cutting plane to prevent persistent biliary fistula. Finally, the resection margins in this case were negative microscopically. The operative blood loss was only 200 ml and the patient had no surgical complication after operation.

In general, right hemihepatectomy is performed when the right intrahepatic bile duct is involved by hilar cholangiocarcinoma. FLR is one of the most important factors associated with posthepatectomy liver failure (PHLF) and PHLF is the most serious complications and a major cause of mortality after liver surgery.\(^8\) In this case, the FLR of left half liver was only 38% after right hemihepatectomy with caudate lobectomy, but patients with abnormal parenchyma need an FLR up to 40% as minimal functional liver volume.\(^9\) Portal vein embolization is widely used to increase FLR. However, it is invasive and may delay the operation and cause complications such as portal thrombosis, infection, and bile leakage. As the 3-dimensional reconstruction images showed only the RASD was involved by tumor and the RPSD draining to LHD was not involved, liver segment 6 and segment 7 could be reserved and only relevant segmentectomy with caudate lobectomy was performed during operation. The FLR was increased from 38% to 70%. Liver parenchyma was preserved to the highest degree on the basis of R0 resection. The surgical planning was guided and the safety was improved by preoperative evaluation of MDCT combined with 3-dimensional reconstruction. The liver function of the patient was well-recovered after surgery.

MDCT combined with 3-dimensional reconstruction is a reliable non-invasive modality for preoperative evaluation of hilar cholangiocarcinoma. Anatomic variation can be preoperatively detected and surgeons can make individualized surgical planning to reserve the liver parenchyma to the highest degree on the basis of R0 resection.

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**REFERENCES**