
Impact of Three-Dimensional Reconstruction Technique in the Operation Planning of Centrally Located Hepatocellular Carcinoma



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- BACKGROUND:** The aim of this retrospective study was to compare the outcomes of operations based on 3-dimensional (3D) operation planning with non 3D-assisted operations in the treatment of centrally located hepatocellular carcinoma.
- STUDY DESIGN:** From April 2008 to March 2014, 116 patients with centrally located hepatocellular carcinoma received surgical treatment in our department. Among these cases, a total of 60 patients received resection with operation planning based on 3D reconstructions (group A); the remaining 56 received treatment with the aid of traditional imaging (group B). Three-dimensional surgical planning, including the classification system for centrally located hepatocellular carcinoma, was elaborated in the study.
- RESULTS:** Compared with group B, group A was linked to shorter operation time (294.5 ± 61.9 minutes vs 324.3 ± 83.1 minutes; $p = 0.028$) and lower rate of hepatic inflow occlusion (51.7% vs 71.4%; $p = 0.029$). No differences were found in surgical methods, intraoperative blood transfusion, and intraoperative blood loss. The groups were similar in their rates of complications, except that group B was more liable to have Clavien Grade III to V complications (3.3% vs 14.3%; $p = 0.048$). In addition, a significant difference in ascites was found across the 2 cohorts (2 in group A and 8 in group B; $p = 0.048$), and the 2 groups also differed significantly in total bilirubin (23.2 ± 16.1 g/L vs 31.1 ± 24.1 g/L; $p = 0.032$) and albumin (29.3 ± 5.2 g/L vs 27.8 ± 7.9 g/L; $p = 0.033$).
- CONCLUSIONS:** Compared with non 3D-assisted operations, the operation planning based on 3D reconstruction is a more effective and reasonable method in the treatment of centrally located hepatocellular carcinoma. In addition, the classification system may facilitate the 3D operation planning. (J Am Coll Surg 2015;220:28–37. © 2015 by the American College of Surgeons)
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Disclosure Information: Nothing to disclose.

Support: This paper was supported by the National High Technology Research and Development Program of China (863 Program) (Grant No. 2006AA02Z346 and 2012AA021105), the Natural Science Foundation of Guangdong Province, China (Grant No.6200171), the strategic cooperation project jointly funded by Guangdong Province and the Chinese Academy of Sciences (Grant No. 2010A090100032), the Science and Technology Project of Guangdong Province, China (Grant No.2011t1031800088 and 2011B031800091), the National Natural Science Foundation of China (Grant No. 81170458), and the Industrial Technology Research and Development Program of Guangdong Province (Grant No. 2012A030400013).

Received June 29, 2014; Revised August 17, 2014; Accepted September 29, 2014.

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Asian countries account for nearly 78% of the roughly 600,000 cases of HCC (hepatocellular carcinoma) reported globally each year.¹ The leading cause is chronic hepatitis B virus infection in Eastern Asia, including China, Hong Kong, Indonesia, Korea, and Taiwan. Chronic hepatitis B virus carriers in Asia account for the majority of the 3.6 billion all over the world.²

Although opinions are widely divided on the treatment of HCC, surgery still dominates in the comprehensive treatment of liver cancer. It can provide opportunities for cure in some patients and can prolong the overall survival time of patients who have surgery. Because the central location of hepatocellular carcinoma can be tricky, it is traditionally resected by right lobectomy (segments V, VI, VII, and VIII), left lobectomy segments II, III, and IV, and extended right/left lobectomy.

Nevertheless, if 60% to 80% of the liver parenchyma is removed, patients will suffer from a risk of significant blood loss and postoperative liver failure, especially for those with cirrhosis or poor preoperative liver function.³⁻⁵

One way to minimize the volume of the resected liver is to remove the central hepatic segments (Couinaud's segments IVA, IVB, V, and VIII), and preserve the functional parenchyma to prevent postoperative liver failure. The first description of central (medial segmentectomy), or now mesohepatectomy, was reported in 1972.⁶

Although mesohepatectomy retains more functional liver tissue, there are still risks of postoperative liver failure because of intraoperative blood loss and time spent controlling intraoperative blood flow. In addition, there may be bilateral damage to key structures, which inevitably has a negative effect on the residual liver function.⁷

Importantly, there are certain groups of patients who cannot tolerate mesohepatectomy (resection of segments IV, V and VIII \pm I) because they have posthepatic cirrhosis. In China, 80% to 90% of liver cancer patients suffer from different degrees of posthepatic cirrhosis, which require individualized operations to preserve more liver parenchyma.⁸

To achieve individualization in the surgical treatment of centrally located hepatocellular carcinoma, 3D reconstruction technology is helpful. Although digital medicine is not recognized by many, it has gained acceptance because it combines computer technology and medicine. The 3D reconstruction technique was introduced to our department about 10 years ago.⁹⁻¹¹ According to our long-term experience using the 3D reconstruction technique in surgery, an individualized preoperative surgical planning process was developed and used for patients with centrally located hepatocellular carcinoma.

This retrospective study aimed to assess the effects of individualized hepatectomy with preoperative planning based on a 3D reconstruction technique for centrally located hepatocellular carcinoma.

METHODS

Ethics statement

The Ethics Committee of Zhujiang Hospital, Southern Medical University, approved this retrospective study and supervised procedures.

Patients

In the Department of Hepatobiliary Surgery of Zhujiang Hospital, the medical records of 116 patients with centrally located hepatocellular carcinoma, who received curative liver resection from April 2006 to March 2014, were retrospectively analyzed.

The patients with centrally located hepatocellular carcinoma were carefully selected using the following criteria:

1. Postoperative histologic examination of the tumor indicated hepatocellular carcinoma;
2. Preoperative CT and/or MRI were used to determine the size of the tumor, with a maximum diameter >3 cm;
3. Tumors were situated mainly in the central segments of the liver (Couinaud segments IV, V, and VIII \pm I);
4. There was no intrahepatic or extrahepatic disseminated disease or tumor thrombus in the main vein trunk;
5. Liver function was evaluated using Child-Pugh Criteria (Child-Pugh grades A and B);
6. The liver remnant after liver resection contained more than 50% of the functional liver volume on CT volumetric assessment.¹²

All patients were informed of treatment details including procedure, risks, and complications, and then were grouped according to whether they had accepted treatment and had preoperative planning using the 3D reconstruction technique. As a result, 60 patients were assigned to group A because they had surgical therapy with preoperative planning based on the 3D reconstruction technique, and the remaining 56 patients were put into group B because they received liver resection only, with preoperative planning based on traditional imaging modalities. To ensure operative quality and safety, all surgical therapies and postoperative management were overseen by the same surgical team.

The technological process of surgery planning based on 3D reconstruction

1. Enhanced CT scanning and CT scanning parameters setting. Data were collected by Philips Brilliance 256-MDCT scanner.
2. Collecting 2D image data and storing data. The 2D images collected by Philips Brilliance 256-MDCT scanner with predefined scanning parameters were processed by MxLiteView DICOM Viewer.
3. Images segmentation and 3D reconstruction. The Medical Image Three-Dimensional Visualization System (MI-3DVS, proprietary software developed by the authors [software copyright No.:2008SR18798].) allowed segmentation and 3D reconstruction of the CT images, in which thin-sliced CT data were imported into the software to facilitate their automatic registration.
4. Surgery planning based on a 3D reconstruction technique. The reconstructed models were exported as Standard Template Library files and imported to the Free Form Modeling System (SensAble Technologies, Inc), on which the spatial distribution of the anatomic structure, hepatic artery blood supply, types of hepatocellular carcinoma, and the variation of hepatic artery were all presented.

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