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New classification-oriented laparoscopic anatomical hepatectomy strategy for hepatocellular carcinoma invading two or more (sub)segments in the left lobe

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With technological advances in laparoscopic hepatectomy and new navigation devices, such as flexible laparoscopic ultrasound probes, indocyanine green (ICG)-fluorescent imaging and three-dimensional imaging, laparoscopic segmentectomy (LS), which maximizes the preservation of the functional hepatic reserve and the possibility for future repeat hepatectomy while ensuring adequate surgical margins, has become a feasible alternative to hemihepatectomy for addressing hepatocellular carcinoma (HCC).[1,2] However, for a single HCC invading two or more (sub)segments in the left lobe, most surgeons automatically choose left hemihepatectomy (LH) without considering the tumor's anatomical distribution due to the relatively smaller volume of the left lobe. In fact, 80% to 90% of HCC patients in China have underlying cirrhosis.[3] Studies have proven that approximately one-third of postoperative hepatic dysfunction or even failure in patients with cirrhosis is attributed to LH.[4,5] As a result, in the current era of minimally invasive surgery, a more precise algorithm is needed to guide the surgical strategies for HCC in the left lobe. Herein, we proposed a new classification-oriented laparoscopic anatomical hepatectomy strategy for a single HCC invading two or more (sub) segments in the left lobe, termed the Wu's classification.

A new classification was devised by focusing on the Couinaud segments involved by the lesion and the lesion's location relative to the principal hepatic vascular structures, in which the lesion was divided into four types [Figure 1A]. Tumors invading segments II and III but not the umbilical plate were classified as type 1. Tumors invading subsegments IVa and IVb but not the middle hepatic vein (MHV), left hepatic vein (LHV) and umbilical plate were classified as type 2. Tumors invading segments IV and II were classified as type 3a, and those invading segments IV and III were classified as type 3b. Finally, tumors invading more than two segments in the left lobe were classified as type 4.

Based on the new classification, laparoscopic left lateral sectionectomy (LLS) could be considered as the recommended procedure for type 1 lesions. For type 2 lesions, segmentectomy IV is recommended. LH is recommended for type 3a lesions, in which the root of LHV is invaded by the tumor, while type 3b lesions require the removal of segment III and IV or subsegment IVb. For type 4 lesions, LH is the recommended procedure. However, the following two points should be noted. One is to ensure the integrity of the blood supply and outflow of the remnant liver to avoid causing ischemia or congestion. The other is to ensure adequate oncological margins. If these goals cannot be achieved, LH should be chosen as an alternative procedure [Figure 1B].

From January 2019 to December 2021, 194 HCC patients with a single lesion invading two or more (sub)segments in the left lobe and preoperative diagnosis based on computerized tomography (CT) or magnetic resonance imaging (MRI),[6,7] were enrolled in this study and underwent the recommended procedures based on our new classification and algorithm. The protocol was approved by the Ethics Committee of Biomedical Research, West China Hospital of Sichuan University (No. 20211682). Informed consent was obtained from the patients and their families. The informed consent highlighted the surgical plan based on the classification

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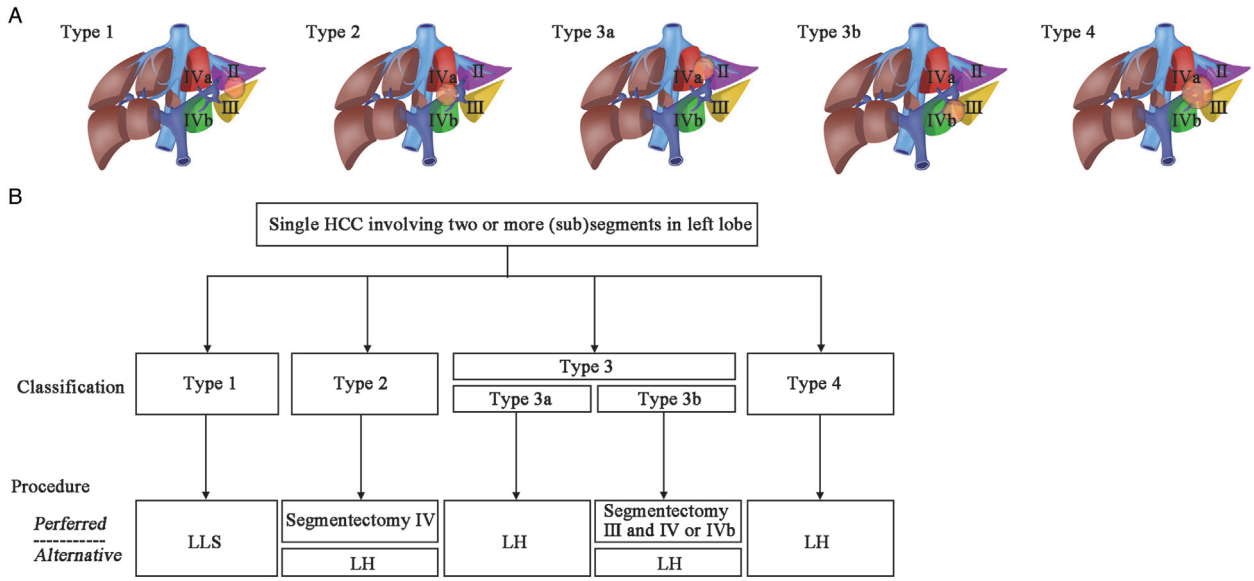

Figure 1: (A) Classification of a single HCC invading two or more (sub)segments. (B) Algorithm for laparoscopic anatomical hepatectomy according to the new classification. HCC: Hepatocellular carcinoma; LH: Left hemihepatectomy; LLS: Left lateral sectionectomy.

and algorithm, advantages, potential risks, and alternative strategies for any incident encountered.

Preoperative evaluation included routine blood test, blood biochemical examination, electrolytes, coagulation function test, and ICG retention test at 15 min for liver function evaluation. Three-dimensional reconstruction (IQQA-liver, EDDA Technology, Princeton, NJ, USA) was performed for volumetric assessment and surgical simulation. The Makuuchi criteria were used to define the acceptable hepatic volume to be resected.[8] Postoperative hepatic dysfunction or failure was diagnosed based on the 50–50 criteria.[9]

Patient 1 had a lesion invading segments II and III (type 1), and LLS was performed. Compared with LH, LLS preserved approximately 130 mL of functional liver volume according to the preoperative CT image-based three-dimensional reconstruction for volumetric assessment [Supplementary Figure 1, http://links.lww.com/CM9/B296].

Patient 2 had a lesion invading subsegments IVa and IVb (type 2), and segmentectomy IV was performed. The round ligament approach, described in our previous study,[10] was used to transect the blood supplies of segment IV. Liver transection was then performed with the assistance of the ICG fluorescent negative staining method. Compared with LH, this procedure preserved approximately 400 mL of functional liver volume.

Patient 3 had a lesion invading segment II and subsegment IVa (type 3a), and LH was performed. The parenchymal transection was also performed under the guidance of intraoperative ultrasonography and the ICG fluorescent negative staining method.

Patient 4 had a lesion invading segment III and subsegment IVb (type 3b). Segmentectomy III plus IV was performed. Intraoperatively, the hepatic pedicles of segments III and IV were identified in the fissure of the round ligament and then divided. The liver parenchyma was transected along the ischemic liver surface. Compared with LH, approximately 134 mL of functional liver volume was preserved by this procedure.

Patient 5 had a lesion invading segments II, III, and IV (type 4), and LH was performed.

The clinical characteristics of 194 HCC patients are summarized in Supplementary Table 1 (http://links.lww.com/CM9/B296). A total of 41.2% ($n = 80$) of patients had pathologically reported cirrhosis. All patients had negative surgical margins, and the median diameter of HCC was 34 ± 12 mm. Forty-eight patients were classified as type 1, 38 as type 2, 20 as type 3a, 33 as type 3b, and 55 as type 4. Type 4 lesions were larger, and the LH and segmentectomy III plus IV had longer operation time and greater blood loss compared with others (all $P < 0.05$). Two cases required blood transfusion intraoperatively. Neither hepatic dysfunction nor failure occurred based on the 50–50 criteria,[9] and all patients were discharged within one week after the operation [Supplementary Tables 1 and 2, http://links.lww.com/CM9/B296].

With advances in laparoscopic technology, more precise anatomical hepatectomies, such as segmentectomy or even subsegmentectomy, have been recommended by updated expert consensus to treat HCC in the right lobe,[11] especially for single small HCC. Anatomical hepatectomy which ensures the vascular integrity of the remnant liver, eradicates potential intrahepatic metastases and maximizes the postoperative functional hepatic reserve, can facilitate rapid postoperative recovery and provide residual functional liver volume in the repeated hepatectomy for recurrent lesions.[12,13] Compared with the right lobe, the left lobe usually has a smaller volume, which

means that even if LH is performed, the risk of postoperative liver dysfunction or failure is lower than that of right hemihepatectomy. However, in some cases, LH can lead to postoperative liver dysfunction and even liver failure.[4] For example, patients with severe liver cirrhosis had an imbalanced volume ratio between the right and left lobes, and those undergoing one or more hepatectomies in the right lobe had a compensatory increase in left liver volume. In these cases, even LH or LLS can remove a large amount of functional liver volume, putting patients at risk for complications. Despite the lower incidence of liver dysfunction and failure, it is catastrophic once it occurs. In this study, of 80 cirrhosis patients, only 31.2% ($n = 25$) classified as type 4 needed LH for treatment [Supplementary Table 2, http://links.lww.com/CM9/B296]. The remaining patients could have the choice of parenchyma-preserving anatomical hepatectomy according to our classification and algorithm. Hence, for lesions in the left lobe, especially for small HCC lesions, it is necessary to perform more precise anatomical hepatectomies like the right liver lesions.

Since there is a lack of a classification system to guide the implementation of individual laparoscopic anatomical hepatectomies to treat a single HCC in the left lobe, we introduced a new classification-oriented laparoscopic anatomical hepatectomy strategy for a single HCC invading two or more (sub)segments in the left lobe. This is an "easy-to-use" algorithm for performing corresponding recommended procedures according to different types. The short-term outcomes of the patients in this study were satisfactory according to this new classification. Certainly, this new classification system is a preliminary exploration; its effect and value need to be further confirmed in clinical practice.

In conclusion, the present classification system of a single HCC invading two or more (sub)segments in the left lobe may guide surgeons to perform more precise laparoscopic anatomical hepatectomy.

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Conflicts of interest

None.

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