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Original Communications

# Hepatic vein management in a parenchyma-sparing policy for resecting colorectal liver metastases at the caval confluence

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**Background.** Patients with tumors involving hepatic vein at the caval-confluence usually receive major hepatectomies or hepatic vein grafting; however, nonnegligible postoperative mortality and morbidity are associated. Authors introduced the tumor-vessel detachment for colorectal liver metastases. Then we reviewed our results applying this approach in patients with colorectal liver metastases in contact with hepatic veins at the caval-confluence.

**Methods.** A cohort of consecutive patients with colorectal liver metastases in contact with hepatic veins at the caval-confluence undergoing liver surgery was reviewed. Relationships were classified as: Type 1: contact/involvement less than a third of hepatic vein circumference; Type 2: contact/involvement in a third to two-thirds; Type 3: contact/involvement in more than two-thirds. Hepatic vein- colorectal liver metastases detachment, or in case of hepatic vein-resection, the sparing of the drained parenchyma, were attempted systematically.

**Results.** Overall 190 colorectal liver metastases-hepatic vein contacts in 135 patients were analyzed. Colorectal liver metastases-hepatic vein detachment was performed in 95 (50%) contacts, partial resection and direct suture in 61 (32%), partial resection and patching in 4 (2%), and hepatic vein complete resection in 30 (16%). Hepatic vein-sparing resection was possible in 102 patients (76%), and major hepatectomy was needed in 1 (0.7%). Operative mortality, overall and major morbidity rate were 0.7%, 32%, and 4%, respectively. Local recurrence rate was 6% (median follow-up: 27 months). Preoperative and intraoperative imaging predicted the need for hepatic vein resection in 99% of patients ($\kappa = 0.971$).

**Conclusions.** Hepatic vein-sparing or a parenchyma-sparing policy is feasible in most patients with colorectal liver metastases-hepatic vein contacts at the caval-confluence. This approach seems safe, predictable, and oncologically adequate, and, upon further confirmation, could become an alternative to major hepatectomies or hepatic vein replacement. (Surgery 2017;160:XXX-XXX.)



Although the use of intraoperative ultrasonography (IOUS) in liver surgery has reduced the need for major hepatectomy (MH), the rate of MH and its related mortality remain nonnegligible.[1-4] For colorectal liver metastases (CLM) in contact with or infiltrating the hepatic veins (HVs) at their caval confluence (CC), a MH generally is considered. However, HV replacement with interposed grafts has been proposed as an alternative.[5,6] In the presence of accessory veins, such as the inferior right hepatic vein, it is possible to spare the liver parenchyma even after sectioning the main draining vein.[7] More recently it has been shown that intrahepatic communicating veins are rather frequent in patients with tumors compressing HVs at the CC.[8] These communicating veins, which can be identified by IOUS, have opened up new parenchyma-sparing options.[9-12] However, authors have described previously the possibility of detaching HCC from glissonean pedicles[13,14] and HV.[15] This policy has since been introduced for CLMs conveying the R1vasc concept,[12,14-18] linked to a recurrence rate similar to R0 resections.[19] Therefore, in the case of tumor and HV contact the need for HV resection could be limited drastically. We have herein reviewed our policy in managing patients with HV-CLM contact in a parenchyma-sparing intent and the ability of preoperative imaging and IOUS to predict the possibility of sparing HVs.

## Methods

### *Definitions*

Liver anatomy and operative procedures were classified according to the Brisbane terminology.[20] Hepatic resections involving at least 3 adjacent segments were defined as MH. Systematic extended right posterior sectionectomy was a bisegmentectomy[6,7]

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extended to part of segment 8 or 5[21]; minimesohepatectomy was defined as partial resection of segment 4 superior and 8 with middle hepatic vein (MHV) resection[9]; upper transversal hepatectomy was defined as removal of segments 7, 8, and part of 4 superior with right hepatic vein and MHV section[10]; liver tunnel (LT) was defined as removal of segments 1, 8, and part of 4 superior,[11] including the MHV at caval confluence in the event of its invasion. Any CLM in contact with the last 4 cm tract of each HV prior to its confluence into the inferior vena cava (IVC) was considered at the CC. Response to preoperative chemotherapy was classified according to the Response Evaluation Criteria in Solid Tumors criteria.[22] Postoperative death was analyzed at 90 days. Morbidity included all postoperative complications, and was scored according to the Clavien-Dindo grading system.[23] The width of the resection margin was defined as the shortest microscopic distance from the tumoral edge to the transection line. Local tumor recurrence was defined as any cut-edge recurrence.

*Eligibility criteria*

All consecutive patients undergoing hepatectomy for CLM at the authors' institution between January 2009 and December 2016 were reviewed. In our institution HV-CLM detachment was attempted systematically, excluding those patients with HV thrombosis or not identifiable because of tumor involvement, and patients with portal pedicle infiltration and/or thrombosis precluding the possibility of performing HV-sparing hepatectomy. These patients and those with <6 months of follow-up after surgery were not considered for the analyses.

*Preoperative management*

All patients were preoperatively staged with thoraco-abdominal computed tomography (CT). Hepatic magnetic resonance imaging (MRI) was performed in selected patients, e.g., patients with multiple bilobar CLM, those receiving preoperative chemotherapy and those with doubtful lesions detected at CT. Positron emission tomography-CT was performed in all patients to disclose associated extrahepatic disease.[24]

The management of all patients involved a multidisciplinary team discussion. Patients receiving preoperative chemotherapy were restaged after 4–6 cycles and scheduled for surgery if disease response or stabilization was confirmed. In the case of disease progression a second-line chemotherapy usually was scheduled. Only patients amenable to complete resection were considered for surgery, regardless of number and size of CLM. In addition, their eligibility for resection was decided on the basis of liver function tests and future remnant liver (FRL), as described elsewhere.[16,25]

*Operative procedure*

J-shaped laparotomy or thoraco-phreno-laparotomy was performed to achieve adequate exposure. The relationship between HV and CLM was classified at IOUS as previously reported,[12,17] and recorded in our prospectively maintained database

Type 1: HV contact/involvement by CLM for less than a third of the circumference (regardless of longitudinal extension).
Type 2: HV contact/involvement by CLM for a third to two-thirds of circumference (regardless of longitudinal extension).
Type 3: HV contact/involvement by CLM for more than two-thirds of circumference.

In the event of type 3 patterns at IOUS was found, an accurate color-flow IOUS was performed as previously reported.[8,12,14,17] If communicating veins were visualized and/or hepatopetal inflow after HV clamping was demonstrated, conservative non-HV-sparing parenchyma-sparing resection was considered. MH was considered only if no parenchyma-sparing resection was possible, and anyway in the presence of an adequate FRL. The authors adopted a cut-off of a minimal FRL of 40% in patients with normal liver, and 50% in patients with cirrhosis.[16,25]

The liver was mobilized by dividing the right and/or left triangular and coronary ligaments to properly control the CC. HVs in contact with the CLM were encircled with tape. Parenchymal-transection was carried out under intermittent pedicle clamping by means of crush clamping, ligatures, and bipolar electrocautery for thinner vessel coagulation. Central venous pressure was maintained between 0 and 4 cm $H_2O$ by means of fluid restriction (of 4–5 mL/kg/h) and reduction of tidal volume to ≈60% during liver transection to limit the backflow bleeding. Whenever needed, the backflow bleeding was controlled by finger-compression technique or HV-clamping.[26]

*Patient follow-up*

The administration of adjuvant chemotherapy was evaluated on a case-by-case basis. Patients' follow-up was scheduled in the outpatient clinic every 3 months after surgery and included clinical examination, liver function tests, tumor markers, and abdominal ultrasonography. CT or MRI was performed at 6-month intervals.

*Study setting*

All data herein reviewed originated from a prospectively maintained database.

This study was registered at ClinicalTrials.gov (ID: NCT02391207).

The CLM-HV relationship was analyzed in all patients using preoperative radiologic images (CT and/or MRI and IOUS). In patients with multiple CLMs or contact of a CLM with ≥1 HV, every single CLM and every single contact were analyzed. Multiple HV-CLM contact, if analyzed in a per patient perspective, were accounted for their most advanced type of relationship.

One expert radiologist blinded to clinical and surgical data reviewed preoperative radiologic images.

*Study end points*

The present study had the following end points:

1) To assess the feasibility of a parenchyma-sparing policy without HV-replacement and as a consequence the reliability of pre- and intraoperative imaging in predicting such feasibility;
2) to assess the safety of a parenchyma-sparing policy without HV-replacement in terms of operative mortality and morbidity;
3) to ascertain the oncologic effectiveness of this policy in terms of local control of the disease (local recurrence risk).
4) to analyze the proportion of patients avoiding major hepatectomy and portal vein occlusion (PVO) thanks to this policy.

*Statistical analysis*

Continuous variables were presented as median (range). Categorical variables were expressed as number and percentage. The overall accuracy, sensitivity, specificity, positive and negative predictive value (PPV and NPV) of preoperative imaging and IOUS in predicting the need for HV resection were analyzed. Cohen's κ coefficient was used to assess the inter-rater reliability of preoperative and intraoperative imaging in predicting HV resection ($\kappa > 0.70$ was considered satisfactory). Overall survival (OS) and hepatic-free

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