From Mesohepatectomy to Mini-Mesohepatectomy: Evolving the Concept of Resectability of Hepatic Tumors at the Hepatocaval Confluence

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Key Words

Mini-mesohepatectomy • Mesohepatectomy • Hepatic resection • Intraoperative ultrasound • Middle hepatic vein • Hepatocaval confluence • Hepatic tumors

Abstract

In the case of tumors in contact with or invading the middle hepatic vein (MHV) at the hepatocaval confluence, extended right hepatectomy or mesohepatectomy is usually recommended. Major or extended hepatectomy is associated with significant rates of morbidity and mortality, and a more conservative approach would be desirable. Thus, we developed a new conservative operation, the so-called mini-mesohepatectomy that, in some specific circumstances, allowed the en-bloc resection of segment 8, segment 4-sup and the MHV at the hepatocaval confluence and at the same time preservation of the remaining parenchyma of the right anterior section and left median section drained by the MHV. The present work describes the rationale, indications, as well as the surgical technique of this new operation which we believe should be part of the armamentarium of the modern hepatic surgeon, and will probably limit the need for a formal mesohepatectomy.

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Introduction

Mesohepatectomy is a major central hepatectomy involving the removal of segments 5, 8, and 4, and resection of the middle hepatic vein (MHV) at the hepatocaval confluence. First described by Hasegawa et al. [1], this complex operation usually requires a full dissection of the hepatic hilum to isolate and ligate the arterial supports and the glissonian branches to the right anterior section (segments 5–8) as well as to the left median section (segment 4). Traditionally, when tumors invade the MHV at the confluence into the inferior vena cava (IVC), a right trisectionectomy is performed by most surgeons, and mesohepatectomy is reserved by others as a conservative alternative to the previously cited operation [2–5]. However, as major or extended hepatectomies – even in experts hands – are associated with significant rates of morbidity and mortality [6–9], a more conservative approach even in such complex tumor presentation is desirable.

Based on a solid knowledge of intraoperative ultrasound (IOUS) and ultrasound-guided hepatic resection aimed to preserve functional liver parenchyma [10, 11], we developed a new ultrasound-guided conservative resection, the so-called mini-mesohepatectomy (MMH) [12].

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Fig. 1. a EF-IIOUS scan shows blood flow into the MHV (arrow). **b** EF-IIOUS scan, taken at the time the MHV has been clamped by the surgeon's finger compression (F), shows that there is no more blood flow (no color signal) into the MHV.

Methods

Definitions

The terminology for liver anatomy and resections used in this work is based on the Brisbane classification [13]. MMH is defined as the partial removal of segments 8 and 4 superior including the involved tract of MHV.

Indications

Candidates for the MMH are patients with tumors with indefinite margins or direct evidence of invasion of MHV at the hepatocaval confluence, which are defined as the tract of the vein within 4 cm from the IVC. Of course, patients with bulky tumors occupying the right anterior section (segments 5–8) and segment 4, as well as patients with invasion of another hepatic vein (right or left hepatic vein), cannot receive this approach.

Operative Technique

Patients are prepared in a standard manner, and positioned in the supine position on the operating table. J-shaped laparotomy incision is generally carried out with the aim to control the hepatocaval confluence by fingertip compression, as described below. Access to the thoracic cavity following the 9th intercostal space is carried out when the control at the hepatocaval confluence is felt as inadequate especially in obese patients, in patients with deep chest, and in reoperation. After a partial mobilization of the liver, IIOUS is performed using an Aloka Alpha 10 (Aloka Ltd; Tokyo, Japan) equipped with the standard 2- to 6-MHz convex probe, 5- to 10-MHz T-shaped probe, and with the 5- to 10-MHz microconvex probe. The intraoperative staging is completed by contrast-enhanced IIOUS, using the dedicated 1.88- to 3.76-MHz harmonic frequency probe, in those patients with doubtful and/or new findings based on our previously reported criteria [14, 15].

At this point, the anterior surface of the hepatocaval confluence is exposed, and the space between the right hepatic vein (RHV) and MHV at the confluence into the IVC is obtained to

Fig. 2. EF-IIOUS scan shows flow in a communicating vein (CV) connecting the MHV and the RHV. T = Tumor.

accommodate the surgeon's fingertip. Fingertip compression is then applied to the MHV to test the feasibility of MMH.

IOUS Criteria for MMH

To perform MMH, at least one of these three criteria should be confirmed once the fingertip is compressing the MHV (fig. 1):

- (1) Reversal flow direction in the peripheral portion of the MHV, which suggests drainage through collateral circulation in adjacent hepatic veins or IVC.
- (2) Detectable shunting collaterals between MHV and right or left hepatic vein (fig. 2).

Fig. 3. **a** Position of surgeon's hands during liver dissection: the surgeon's left hand sustains the right hemiliver, with the 1st finger keeping the dissection area opened, the 2nd finger positioned on the posterior aspect of the line drawn with the electrocautery on the glissonian capsule and the 3rd finger positioned in the fossa

between RHV and MHV caval insertion for backflow bleeding control in the event it would be needed. **b** The resection area at the end of the MMH results in a parenchyma-sparing hepatectomy, but with a flat and smooth cut surface.

(3) Hepatopetal flow in P5–8 and/or P4-inferior portal branches.

If none of these criteria is confirmed, MMH is not feasible. In particular, in the case of hepatofugal flow direction in the P5–8 and/or P4-inferior branches, the resection has to be extended to the parenchyma fed by those portal branches, i.e. a formal mesohepatectomy has to be performed.

Practically, these criteria are extensively searched using color Doppler IIOUS and more recently adopting almost exclusively E-flow IIOUS (EF-IIOUS). The latter is a highly sensitive directional flow evaluation modality which allows flow detection independent of the angle used for scanning the vessel: indeed, the wrong angle of scanning at color Doppler examination is one of the main reasons for unreliable evaluation. In this way, EF-IIOUS allows more reliable studies and analysis of slow motion blood flows in thin vessels like collateral hepatic veins.

Once at least one of the aforementioned criteria has been confirmed, full mobilization of the right and left hemiliver is performed dividing the triangular and coronary ligaments, without hepatic vein taping and preserving most of the short hepatic veins. Only in the case of true invasion of the MHV by a tumor in the paracaval portion of segment 1, should such short hepatic veins be divided. Thus, the area of resection could be marked on the liver surface by IIOUS, and its extension should depend on the surgical plan. Indeed, both anatomical segmental or subsegmental resection as well as non-anatomical or limited resection might be used, and several surgical techniques have already been described [16–18]. Apart from the case of hepatocellular carcinoma, non-anatomical or limited resections are generally performed. Briefly,

under IIOUS control, the electrocautery between the probe and the liver surface allows to define the caudal and lateral portions of the resection area, while the surgeon's fingertip pushing the liver from the most cranial portion is visualized on the ultrasound scan and allows to define the cranial limit of the resection area, and then the dissection plane. Electrocautery is then used to draw the resection area on the liver surface. Dissection is carried out with the surgeon's left hand sustaining the right hemiliver with his 1st finger keeping the dissection area opened, the 2nd finger positioned on the posterior aspect of the line drawn with the electrocautery on the glissonian capsule and the 3rd finger positioned in the fossa between RHV and MHV caval insertion for backflow bleeding control in the event it would be needed (fig. 3a). The main objective, once the resection area is drawn, is to achieve the flattest and smoothest cut surface (fig. 3b). The posterior wall of the MHV or of the tumor itself is used as the deepest landmark of the resection area. IIOUS guidance is used to follow the dissection plane getting closer to the targeted point for MHV division.

Discussion

The rate of major hepatic resections represents approximately half of the resections performed in most centers, and the associated mortality and morbidity are not negligible [6–9]. Therefore, the need to reduce that rate

should be one of the priorities in hepatic surgery, and indeed some authors have proposed alternative approaches in selected patients [19–22]. However, in the case of tumor touching or infiltrating the MHV, most of the authors would suggest performing extended right hepatectomy, probably with preoperative portal vein embolization, while others might consider mesohepatectomy, which is a valid conservative alternative.

Following our previously reported studies, in which we have shown the feasibility and reliability of ‘the radical but conservative approach’ for liver tumors with complex vascular relations [10, 11], we developed MMH, a new operation that further enhances the concept of parenchyma sparing in liver surgery [12].

It could be argued that the preservation of part of the right anterior section and of the left median section without the MHV represents a risk for venous congestion that might be a source of morbidity. In fact, based on previous studies, only 24% of patients had communicating veins between MHV and RHV, and just 43% of patients who received the right liver without MHV after living donor liver transplantation had no residual congested areas based on color Doppler evaluation of portal branch blood flow direction [22]. However, we did not experience a single case of congestion, and this is strictly related to the extensive use of EF-IIOUS which has allowed the disclosure of communicating veins between adjacent hepatic veins in most patients with tumor located at the hepatocaval confluence. Indeed, in a recent report we have shown how communicating veins appear on EF-IIOUS in 80% of such patients [23].

A second concern that might be raised regards the surgical margin. From the oncological standpoint, many studies have previously reported that the width of the surgical margin was not correlated with the true recurrence rate [24, 25]. In particular, the zero margin in the case of hepatocellular carcinoma did not increase the risk of recurrence as shown by our previous reports [10, 11], and as recently confirmed by Matsui et al. [25] in a large series of patients. On the other hand, also in the case of liver metastases, the 0-mm margin is progressively becoming acceptable [26, 27]. When oncologically acceptable, the parenchyma sparing policy has allowed us to perform surgery in a single session in cases of multiple bilobar colorectal cancer liver metastases [28]. These patients need to be radically operated on with a single procedure. If they are carriers of lesions located at the hepatocaval confluence, they will benefit from the combination of procedures such as the herein described MMH and the previously reported SERPS. This is an example of an ap-

plication of MMH which makes otherwise unfeasible surgical approaches feasible, at least in a single procedure. Certainly, a parenchyma-sparing technique such as MMH, when oncologically acceptable, would be a welcomed option in cases where the suitability of the surgical treatment of hepatocellular carcinoma has to be evaluated. Indeed, although a hepatocellular carcinoma invading a hepatic vein is a less frequent occurrence when compared with metastatic lesions, there is room for the surgical treatment anyway [29], and for that the suitability of a parenchyma-sparing option such as MMH could be crucial for the decision to proceed or not.

In conclusion, MMH for removal of tumor in segment 8 or segment 4-sup that is in contact with or infiltrating the MHV is a feasible, safe and effective operation, and we believe should be part of the armamentarium of the modern hepatic surgeon. Its application will probably drastically limit the use of formal mesohepatectomy. The latter is somehow controversial due to the technically demanding double-cut surface, and the insufficient benefit in terms of parenchyma sparing. Formal mesohepatectomy could now be replaced by a technique which promotes a drastic limitation of parenchyma removal (fig. 3). Application of MMH is more versatile; it can be used also in combination with other resection and offer a better solution for the surgical treatment of patients with complex presentations.

Disclosure Statement

The authors have nothing to disclose.

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