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Liver remnant hypertrophy induction – How often do we really use it in the time of computer assisted surgery?

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ABSTRACT

Purpose: To evaluate the significance of the hypertrophy concept in patients requiring extended liver resections for colorectal metastasis in the time of computer assisted surgery.
Methods: Retrospective analysis of patient collective undergoing major liver surgery. 2D CT, 3D CAS with Fraunhofer MeVis Sofware. Portal vein embolisation (PVE) with the Amplazer Plug, portal vein ligation (PVL) as 1. Stage operative procedure.
Results: 2D CT data identified 29 patients out of 319 (2002-2009) to be at risk for liver failure after resection. After 3D CAS analysis and virtual operation planning, only 7/29 were at true risk and were submitted to portal vein occlusion (PVO). Another 5 patients were submitted to the hypertrophy concept for intraoperative finding of insufficient parenchyma quality. In total, 12 patients underwent PVO (6 PVE/6 PVL). 9/12 patients went to stage 2 and were successfully operated. There was no difference in future remnant liver volume (FRLV) gain or waiting time to step 2 between the groups, though survival was better in the PVE group.
Conclusion: PVO is an effective approach if the patient's future remnant liver (FRL) is too small on 2D CT volumetry. 3D CAS has great impact on the analysis of FRL capacity and in augmenting resectability - in our experience only patients with insufficient FRLV on the virtual resection plan have to take the risk of PVO to maintain the chance of liver resection.

Key words: computer assisted surgery, PVL, PVE, liver hypertrophy, liver resection, virtual surgery planning

INTRODUCTION

Liver surgery remains the most effective therapy for most malignant primary or secondary liver lesions. Factors considered in favour of operability are: sufficient liver remnant volume, technical resectability and extent of comorbidities. Extrahepatic tumour growth and positive lymph nodes in the hilum are no longer contraindications for operation, as long as they are resectable [1]. Hepatobiliary surgeons are most often challenged with patients suffering from colorectal metastases to their liver. Only 15-20 % of these patients are considered resectable at first presentation [2], which explains the tremendous effort that has been made over the last years to achieve a resectable situation for these patients [3,4].

In the 1980s Japanese surgeons reported a new technique of increasing resectability rates using portal vein embolization [5,6]. The idea of the method uses the regenerative potential of the liver – after embolising the portal branch of the side that is to be resected, hypertrophy induction in the future remnant liver (FRL) can be observed in a matter of weeks, leading to a sufficient remnant size and therefore allowing resection in patients that would not have been operable before. Today, the method is considered part of the arsenal of a modern hepatobiliary unit [7-9].

Technical advances have led to a better understanding of functional liver anatomy, surgeons can nowadays visualize their patients liver in 3D and plan operations accordingly [10,11]. Using state of the art software tools (MeVis Software), the total and functional capacity of the liver remnant can be calculated, providing a very accurate estimation of the size of the remnant. Overlooking 300 consecutive cases we are now aiming to clarify the real impact the hypertrophy concept has had in augmenting resectability in our patient collective in the era of implementation of computer assisted surgery (CAS).

MATERIALS AND METHODS

A retrospective research of our hepatobiliary patient database was performed to identify all patients that underwent either portal vein embolization (PVE) or portal vein ligation (PVL) to induce hypertrophy in the future liver remnant. Another search consisted of identifying all patients undergoing major hepatectomies and extended liver resections with small liver remnants to identify the population at risk for postoperative liver failure. Following departmental policy, all patients undergoing major liver surgery had a workup of their computed tomography (CT) data with Fraunhofer-MeVis® Software Tools to get a virtual resection plan. 2D CT scans and 3D virtual resection planning data were compared in these cases to find out if the 3D data actually changed the plan in terms of going to the operation room instead of using a hypertrophy concept. An in depth statistical analysis other than a Kaplan-Meier-survival curve was not performed, as the patient cohort lacks the size for a well powered statistical conclusion.

Patients

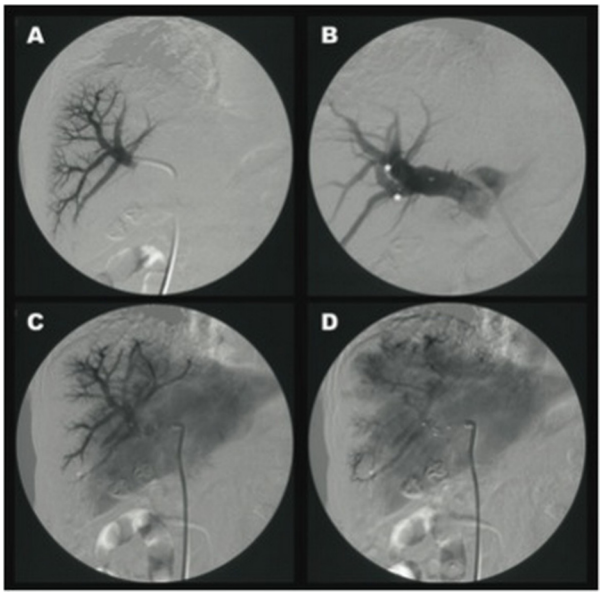
From March 2002 to August 2009 we performed 319 liver resections in our patient collective. Most patients required liver surgery for colorectal liver metastasis (CRLM, n=183), other indications for liver resection were primary liver tumours (n=40), Klatskin tumour (n=16), gallbladder carcinoma (n=10), metastases of other primaries (n=28), and benign tumours and conditions (n=42). All patients received 2D CT scans. CT data of patients planned for major hepatectomy were processed with 3D reconstruction of the CT data for virtual resection planning using Fraunhofer-MeVis HepaVision® Software.

If a hypertrophy concept was implemented, patients were receiving follow up CT scans that were analysed with the CAS software. Once a sufficient remnant volume was documented we went for operation.

PVE

Preoperative PVE was performed using the Amplatzer Vascular Plug (AVP) (AGA Medical, Golden Valley, MN, USA), a device originally intended for arterial and venous embolization in peripheral vessels (*Fig. 1*). After ultrasound-guided transcutaneous and transhepatic direct puncture of the left portal vein (in one patient a middle portal vein branch was used for access) a 6 or 8 Fr sheath was placed and a diagnostic catheter was introduced in the right portal vein over a guidewire. Polyvinyl alcohol particles (PVA) where injected into the target vessels in order to reduce the flow in the vessel system and to embolise small branches in the periphery. Multiple branches of the right portal vein were then embolised (in one patient also a middle portal vein branch) using 12, 14 and 16mm AVPs (1-3 AVPs needed per patient). Plug position was confirmed by immediate control portography as well as CT and Doppler ultrasound following the next day.

Figure 1A-D. **A: After ultrasound-guided transcutaneous and transhepatic direct puncture of the left portal vein a diagnostic catheter is placed in the right portal vein over a guidewire. B: Implantation of a 16mm AVP distal in the right branch (*) after injection of PVA particles. C: Placement of a second AVP (14mm) further proximal in the same vessel. D: Immediate control portography reveals reduced flow in the right portal vein branches.**



Surgery

The extent of resections varied, whenever feasible, a parenchyma saving strategy was used. 113 of our patients underwent hemihepatectomy (80 right; 33 left), while extended liver resections were done in 58 patients (36 extended right; 18 extended left; 4 mesohepatectomies). Liver resection was performed using an ultrasonic aspirator device and titanium clips. All patients were followed up since operation (mean follow up 23.3 months, range 6-51 months).

In cases where the liver remnant during surgery was classified as potentially too small, e.g. because of steatosis >20% or steatohepatitis following chemo (intraop biopsy), a hypertrophy concept was used based on intraoperative findings. We used the concept in patients with CHILD A