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Portal vein embolization with plug/coils improves hepatectomy outcome

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ABSTRACT

Background: Portal vein embolization (PVE) has become the standard of care before extended hepatectomy. Various PVE methods using different embolization materials have been described. In this study, we compared PVE with polyvinyl alcohol particles alone (PVA only) *versus* PVA with plug or coils (PVA + plug/coils).

Materials and methods: Patients undergoing PVE before hepatectomy were included. PVA alone was used until December 2013, thereafter plug or coils were placed in addition. The volume of left lateral liver lobe (LLL), clinical parameters, and liver function tests were measured before PVE and resection.

Results: A total of 43 patients were recruited into the PVA only group and 42 were recruited into the PVA + plug/coils group. There were no major differences between groups except significantly higher total bilirubin level before PVE in the PVA only group, which improved before hepatectomy. Mean LLL volume increased by 25.7% after PVE in the PVA only group and by 44% in the PVA + plug/coils group ($P < 0.001$). Recanalization was significantly less common in the PVA + plug/coils group. In multivariate regression, initial LLL volume and use of plug or coils were the only parameters influencing LLL volume increase. The postoperative liver failure rate was significantly reduced in PVA + plug/coils group ($P = <0.001$).

Conclusions: PVE using PVA particles together with plug or coils is a safe and efficient method to increase future liver remnant volume. The additional central embolization with plug or coils led to an increased hypertrophy, due to lower recanalization rates, and subsequently decreased incidence of postoperative liver failure. No additional procedure-specific complications were observed in this series.

1. Introduction

Partial hepatectomy has become the standard of care for an increasing number of patients with primary and metastatic malignancies over recent years [1,2] due to expanding resectability criteria. Resectability criteria demand negative margins and sufficient future liver remnant volume (FLRV) [1,3]. Extended right hepatectomy carries a high risk of

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postoperative liver insufficiency. Patients with smaller future liver remnant (FLR) develop more complications after hepatectomy [4–7], and FLRV cutoffs of 25% of total liver volume (TLV) in healthy subjects and 40% in patients with underlying parenchymal liver disease have been proposed [4,5,8]. To better quantify the FLR function, volume function analysis using a global liver function test combined with volumetric analysis by cross-sectional imaging can be carried out [9–11]. Portal vein embolization (PVE) was first described in the 1920s and is an accepted routine intervention to increase FLR preoperatively [12]. After portal vein occlusion, compensatory hypertrophy of the contralateral and atrophy of the embolized lobe occurs. Therefore, embolization of the right portal vein facilitates safe extended right hepatectomy, typically after 3–6 wk [13]. Low complication and good proliferation rates make PVE the therapy of choice for many patients [14,15]. Because of high heterogeneity of the left lateral liver lobe (LLL) volume [5] and underlying parenchymal liver disease in some patients, high proliferation rates are required to minimize postoperative morbidity. It is known that proliferation rates and safety profiles differ between PVE approaches [13]. The choice of the embolization agent is therefore of great importance. There is no accepted gold standard procedure for PVE procedure and several different agents are used. In this study, we compared the preoperative course of liver proliferation after embolization with polyvinyl alcohol particles (PVA) combined with a vascular plug or coils compared with PVA particles alone with an emphasis on the clinical outcome after extended right hepatectomy.

2. Materials and methods

2.1. Study design

This prospective observational study was performed in the Department of General, Visceral, and Transplantation Surgery, in cooperation with the Department of Diagnostic and Interventional Radiology at a tertiary care center (University Hospital Charité, Berlin). All patients who were scheduled to undergo PVE before partial hepatectomy were screened for inclusion. The study ran between January 2005 and spring 2014. Until January 2012, local policy was to perform PVE with PVA only and after that time additional plug or central coils were used to overcome potential revascularization risk. Thus, patients were divided into two study groups: PVA only or PVA + plug/coils. Patients between 18 and 75 y-old with contrast-enhanced computer tomography (CT) or magnetic resonance imaging (MRI) scan within 2 wk were included. Exclusion criteria were as follows: any history of previous liver surgery (excluding cholecystectomy) or severe infectious diseases (e.g., HIV). An additional CT or MRI scan was performed immediately before hepatectomy. Patients in the PVA + plug/coil group underwent an MRI during the third postoperative month. Clinical and standard biochemical parameters were collected at the time before PVE, before hepatectomy, and at the first, third, fifth, 10th, and 85th postoperative day. Additionally, a LiMAx test (MAximal Liver function capacity) was carried out at all study visits. Complications after PVE procedure and hepatectomy were assessed using the Clavien–Dindo classification [16]. An American Society of Anesthesiologists score (ASA score) was recorded before hepatectomy [17,18].

The study protocol had received prior approval by the local ethics committee, and informed consent was collected from all subjects before the inclusion. The trial was performed in accordance with the precepts established by the Helsinki declaration.

2.2. Portal vein embolization

The procedure was performed using a standardized technique by one of six interventional radiologists using the approach as described previously [19]. Briefly, percutaneous ipsilateral transhepatic access was established, and portal vein anatomy was visualized using direct portography. Branches of the right portal vein were selectively catheterized and embolized with PVA particles (500–710 μm Contour; Boston Scientific, Natick, MA) until complete stasis was achieved. In the PVA + plug/coil group, an Amplatzer vascular plug type I or II (St. Jude medical, St. Paul, MN) and/or large coils (Tornado or Nester Coils 6–10 mm in diameter; Cook Medical, Bloomington, IN) were also inserted to seal the entry of the right main branch or branches, in addition to PVA particles. The first centimeter distal to the branch of the left portal vein was left free of plug or coil material because of the need to clamp the right portal branch during portal vein resection. In cases with sufficient right portal vein length, a plug was placed, whereas coil embolization was performed when the right portal vein was too short for plug placement. Additional coil embolization was necessary in some cases when complete thrombosis of the plug was not achieved after 10 min. When segment 4 portal vein branches arose from the left portal vein, these branches were not embolized. The success of PVE was determined by direct portography.

Recanalization of the embolized right portal branch was defined as visible perfusion of the right portal branch distal to embolization on imaging prehepatectomy, as determined by an experienced radiologist.

2.3. Liver function

Liver function was assessed with the LiMAx (MAximum Liver function capacity) test as previously described [9,20]. Based on the hepatocyte-specific metabolism of the ^{13}C-labeled substrate Methacetin (Euriso-top, Saint-Aubin Cedex, France) by the cytochrome P450 1A2 enzyme, which is ubiquitously active throughout the liver, ^{13}C-methacetin is instantly metabolized into acetaminophen and the demethylated ^{13}C-group after its intravenous injection (2 mg/kg). It then gets converted into $^{13}CO_2$ and exhaled, leading to a significant alteration of the regular $^{13}CO_2$: $^{12}CO_2$ ratio in the expired breath. A FLIP device at the patient's bedside measures this change (Humedics, Berlin, Germany) and breath analysis is performed automatically.