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ORIGINAL ARTICLE

Effects of clamping procedures on central venous pressure during liver resection

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Bleeding;
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Summary
Background: Various clamping procedures are used to decrease bleeding during liver resections but their effect on central venous pressure (CVP) remains unclear. The aim of this study was to assess the variations of the CVP during two different clamping procedures.
Methods: We retrospectively reviewed 29 patients (19 males, 10 females) who had Pringle maneuver (PM) and clamping of the inferior vena cava below the liver (IVCC) during major liver resections.
Results: Mean decrease of the CVP after PM, IVCC, and PM + IVCC was 0.84 ± 1.37, 2.17 ± 2.13 and 3.17 ± 2.56 cmH_2O, respectively ($P = 0.02$, $P < 0.0001$ and $P < 0.0001$, respectively). IVCC was more effective in inducing a decrease of the CVP than PM alone ($P < 0.05$). The combination of both PM and IVCC induced the greatest decrease but not to a level of significance compared to IVCC alone ($P = 0.25$).
Conclusion: IVCC remains the more efficient procedure to lower the CVP. However, although PM is commonly used to control vascular inflow within the liver its significant influence on the CVP could participate to the reduction of bleeding during liver resections.

Introduction

Liver resection has become a much safer procedure over the past 10 years and major liver resections are now increasingly used for the treatment of both benign and malignant hepatic tumors [1,2]. One factor that has contributed to the improvement in postoperative morbidity is the control of intraoperative bleeding, since massive blood loss and perioperative blood transfusion have a negative impact on postoperative complications and the recurrence of malignant tumors [3—8]. Reduction of blood loss involves two

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mechanisms: reduction of the inflow by Pringle maneuver (PM), and reduction of the backflow from the major hepatic veins. The safest method to reduce backflow is lowering of the central venous pressure (CVP). Anesthesiological management using fluid restriction, reverse Trendelenburg position and administration of diuretics, nitro compounds and opioids if necessary are effective in reducing the CVP (< 5 cmH_20) [9—12]. An alternative method is selective clamping of the inferior vena cava below the liver. This technique of infrahepatic inferior vena cava clamping (IVCC) was first developed by Otsubo et al. to control the CVP during liver resection [13]. While total hepatic vascular exclusion (THVE) can be considered as the most effective method to achieve a bloodless hepatic transection, the infrahepatic and suprahepatic IVC clamping can induce major central hypovolemia which is a critical issue [14]. In contrast, IVCC has shown to be effective without any deleterious effect on renal function [13], and could be more effective on bleeding than anesthesiologic management alone [12,15]. However, reduction of the inflow by PM could also have an impact on CVP through lowering the venous return from the major hepatic veins. Only few studies have suggested the possible impact of inflow clamping on backflow bleeding from hepatic veins, but they did not assess the impact of PM on CVP [16—18]. The aim of the present preliminary study was to measure CVP levels during liver resection performed with PM, IVCC or combined PM + IVCC.

Patients and methods

Patients

All patients undergoing liver resection between January 2012 and May 2013 at the University Hospital of Clermont-Ferrand, France, were eligible for the study. Patients who underwent successively PM alone, IVCC alone and combined PM + IVCC during the liver transection were included retrospectively. Patients with cirrhosis were excluded from the study because hyperdynamic state and possible underlying cardiomyopathy could affect the interpretation of the results.

Surgical technique

All the procedures were supervised by the same surgeon (EB). Laparotomy was performed through a J-shaped incision. After exploration of the abdominal cavity and assessment of resectability using intraoperative ultrasonography, *pars flacida* of the less omentum was sectioned and the hepatic pedicle taped with a vessel loop to prepare PM. IVC was dissected below the liver and also taped with a vessel loop to prepare IVCC. Parenchymal transection of the liver was performed using an ultrasonic dissector (CUSA dissectron, Integra, Mérignac, France). Hemostasis of small vessels was obtained with bipolar coagulation (Codman, Johnson-Johnson, Rayhham, USA); large vessels and glissonian structures were clipped or ligated.

Clamping policy

Our policy during transection in non-cirrhotic liver is to perform intermittent PM systematically, whatever the value of initial CVP. According to Brooks et al. we perform usually 10 minutes of PM followed by 5 minutes of declamping to minimize liver injury [19]. At the end of this first procedure, when efficiency of PM is considered as limited (excessive or troublesome bleeding for the surgeon), IVCC is then performed alone during ten minutes as well followed by 5 minutes of declamping. As for PM, if this second procedure is considered as limited or insufficient, PM and IVCC are finally performed in combination, for ten minutes, and repeated until the end of the parenchymal transection. During IVCC, a decreased of the mean arterial pressure below 80 cmH_20 is defined as hemodynamic intolerance and leads to loosen gradually the tape around the IVC to restore arterial pressure above 80 cmH_20. Patients that underwent these three clamping procedures successively and in this sequence (PM, IVCC and PM + IVCC) were finally included for analysis.

Anesthetic management and measurement of CVP

Anesthesia was induced with propofol (2 mg/kg), sufentanil (0.2—0.3 μg/kg), and cisatracurium (0.15 mg/kg) and was maintained with desflurane to target a bispectral index (BIS Technology, Aspect Medical Systems, Meern, The Netherlands) between 40 and 50. After tracheal intubation a positive end-expiratory pressure of 5 cmH_2O was maintained, except during liver transection to prevent an increase in CVP. Prophylactic antibiotics were given as recommended by national guidelines [20]. CVP was measured continuously during surgery, using a kit for the monitoring of disposable pressure transducer (TruWave ref. C019004, Edwards Lifesciences LLC) through a catheter inserted in the jugular or the sub-phrenic vein. Low CVP was maintained before and during liver transection by intraoperative fluid restriction (1 mL/kg/h of lactated Ringer's solution as previously described [21]) but our policy is not to use diuretics, nitro compounds or opioids. For each episode of suspected hypovolemia, defined as a change in stroke volume > 10% from baseline, a 250-mL colloid bolus (6% hydroxyethyl starch 130/0.4) was delivered over a 5-minute period. At the end of the parenchymal transection, CVP was increased back to normal values (10—15 cmH_20). CVP before clamping maneuvers was designated as base-CVP and CVP between clamping maneuvers as rest-CVP.

Postoperative data

Postoperative complications were reported according to the classification of Dindo-Clavien [22]. Liver failure was defined as total serum bilirubin > 50 micromol/L and prothrombin time < 50% on postoperative day 5 [23]. Postoperative death was analyzed at 30-days.

Statistical analysis

Statistical analyses were performed with STATA software (version 12; StataCorp, College Station, USA). To study the evolution of central venous pressure, presented as the mean ± standard deviation (SD), and to compare values after each different clamping procedures, data analysis were performed using mixed models which allow to consider, one hand, time as fixed effect and, other hand, the intra-subject variability (with subject as random effects); residual normality was checked. The tests were two-sided, with a type I error set at $\alpha = 0.05$. Values of CVP are expressed as mean ± standard deviation. Clinical data are expressed as median (range).