The American Journal of Surgery 213 (2017) 943–949

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Comparison of three caval reconstruction techniques in orthotopic liver transplantation: A retrospective review

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ARTICLE INFO

Article history:
Received 21 December 2016
Received in revised form
31 January 2017
Accepted 15 March 2017

Keywords:
Liver transplantation
Outcomes
Surgical techniques

ABSTRACT

Background: Classic caval reconstruction during liver transplantation involves complete cross-clamping and resection of the recipient inferior vena cava (IVC) followed by donor IVC interposition. Other techniques preserve the IVC, with piggyback (PB) to the hepatic veins or side-to-side (SS) caval anastomosis. Avoidance of cross-clamping may be beneficial for minimizing hemodynamic instability and transfusion requirements.

Methods: Retrospective review of a provincial transplant database (2007–2011). MELD score was used to measure disease severity. Intraoperative blood loss and volume resuscitation were compared between three caval reconstruction techniques using ANOVA.

Results: 200 deceased-donor transplants (Classic:58, PB:72, SS:70) were included. Baseline disease severity was equal. Mean case duration was shorter in the PB technique (Classic:366, PB:306, SS:385 min, $p < 0.001$). Despite similar blood loss, there was significantly less cell saver return, FFP, platelets, and overall resuscitation volume (Classic:12.8, PB:9.5, SS:13.2 L, $p = 0.001$) utilized in the piggyback technique.

Conclusions: The PB technique was faster and used less cell saver return, FFP and platelets, despite similar blood loss. Availability of different caval reconstruction techniques allows for a breadth of options in difficult cases.

1. Introduction

Classic description of caval reconstruction during orthotopic liver transplantation involves a retrohepatic caval resection. This requires cross-clamping of both suprahepatic and infrahepatic inferior vena cava (IVC) followed by interposition of the donor IVC and liver graft. The duration of cross-clamping required to complete the vascular anastomosis before reperfusion can contribute to portal venous congestion, decreased venous return, and reduction in cardiac output.

Other techniques involve complete recipient hepatectomy with preservation of the IVC, followed by piggyback (PB) to the hepatic veins, or side-to-side (SS) caval anastomosis. These latter techniques only require partial occlusion of the IVC and allows maintenance of some venous return during caval anastomosis. Thus, avoidance of complete cross-clamping may carry benefits for hemodynamic stability, blood loss, and transfusion requirements. In the piggyback technique, the donor suprahepatic IVC is anastomosed to the recipient hepatic veins. In the side-to-side technique both IVC are anastomosed after performing a longitudinal venotomy on the cava.

All three techniques are practiced in parallel at our institution by three transplant surgeons who each have their own preference for the caval reconstruction. This allows the unique ability to compare these methods while the perioperative anesthetic, transplant medicine, and intensive care are maintained by the same group of providers.

The primary objective was to compare intraoperative resuscitation requirements between caval reconstruction techniques. We hypothesized that the three techniques are equivalent with respect to blood losses and resuscitation requirements both intraoperatively and within the first 24 h in ICU.

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http://dx.doi.org/10.1016/j.amjsurg.2017.03.045
0002-9610/

2. Material and methods

Ethics approval for this study was obtained through the University of British Columbia Research Ethics Board, Vancouver Coastal Health Research Institute, and British Columbia Transplant Services.

2.1. Outcomes

Primary outcomes measured were total blood loss and intraoperative volumes given during the procedure and within the first 24 h post procedure in the intensive care unit (ICU). Secondary outcomes were morbidity and mortality post liver transplant.

2.2. Patients

All adult deceased donor liver transplant recipients between January 1, 2007 and December 31, 2011 were identified via the prospectively collected British Columbia Transplant database. Recipient characteristics (age, Child-Pugh, MELD, etiology of liver failure, Canadian Waitlisting Algorithm in Transplantation listing status) were obtained from the database. Retrospective review was performed of the recipients' paper and electronic charts.

Recipients were grouped by caval reconstruction technique as described in the operative report. Pre-transplant Model of End Stage Liver Disease (MELD) score was used as measure of disease severity. Mean intraoperative blood loss and volume resuscitation were compared using ANOVA and Tukey's LSD to identify significant differences between groups. Sub-analyses were performed on individual resuscitation components (blood products, crystalloid, colloids). Continuous variables were reported as means with standard deviations where appropriate. Categorical variables were compared using chi-square test. Significance was set at <0.05 for all statistical tests.

2.3. Description of surgical technique

All transplants were performed within a single tertiary care hospital by three transplant surgeons. Each surgeon primarily practices one technique of caval reconstruction. Technique selection for individual transplants was determined by surgeon preference and technical feasibility. Each surgeon had a favored technique but crossover to other techniques was utilized at the surgeon's discretion. The technique used was confirmed by the operative report.

2.3.1. General description of transplant procedure

Following laparotomy and mobilization of the native liver, control of vascular inflow is obtained by isolation of the hepatic artery and portal vein. Venous control of the IVC or hepatic veins is then obtained, depending on the technique utilized. Native liver hepatectomy is performed. The donor liver is then brought into the operative field and caval, portal vein, and hepatic artery reconstruction performed. The variations in caval reconstruction are graphically represented in Fig. 1. Reperfusion is performed by declamping first the portal vein (PV) or hepatic artery (HA) followed shortly by the hepatic veins or IVC. Biliary reconstruction and abdominal closure are completed and then patients are directly transported to the intensive care unit for postoperative care.

2.3.2. Classic variation

The IVC is dissected and encircled distal to the hepatic veins and proximal to the renal veins, with complete cross-clamp. The IVC is divided and removed with the native liver. The IVC of the donor liver is then interposed and vascular anastomoses performed.

2.3.3. Piggyback variation

Complete hepatectomy is performed keeping the IVC intact. Short hepatic vein branches joining the caudate lobe to the IVC are divided in order to fully mobilize the liver off the IVC. The right hepatic vein is dissected and divided with a vascular stapler. Vascular clamp is placed across the confluence of the left and middle hepatic veins. The portal and hepatic veins are divided, and the native liver is removed. Anastomosis is then performed between the donor IVC and the confluence of the recipient left and middle hepatic veins. Alternatively, depending on patient anatomy, a variation of this technique is to anastamose to the confluence of all three hepatic veins.

2.3.4. Side to side variation

Following complete hepatectomy, all three hepatic veins are dissected and divided with a vascular stapler. Proximal and distal ends of the donor IVC are controlled using a vascular stapler prior to implantation. Vascular clamp is placed on the recipient IVC without causing complete occlusion. Longitudinal venotomies are made in both the recipient and donor IVC and anastomosis performed.

3. Results

200 deceased-donor transplants performed in 191 patients were included. One patient was excluded from the analysis because the caval reconstruction technique could not be obtained from the operative report. Patient characteristics are summarized in Table 1. The main etiologies of liver failure requiring transplantation were chronic hepatitis C, primary sclerosing cholangitis, and alcoholic cirrhosis. Concurrent hepatocellular carcinoma was found in 12% ($n = 25$) of patients. Baseline disease severity as measured by the MELD score was equal between groups.

The classic technique was used in 29% of transplants ($n = 58$). All three surgeons utilized this technique, though 84.5% ($n = 49$) of classic transplants were performed by the same surgeon. The piggyback technique was used in 36% of transplants ($n = 72$) by two surgeons, 87.5% of which were performed by the same surgeon. The side-to-side technique was used in 35% of the transplant ($n = 70$) by all three surgeons, of which 85.7% ($n = 60$) were performed by the same surgeon. Intraoperative construction of temporary portocaval shunts was performed in 17% of piggyback and 54% of side-to-side cases. No patients were placed on veno-veno bypass.

Intraoperative resuscitation volumes are summarized in Table 2. The overall case duration was significantly shorter in the piggyback group. However, there was no difference in the warm ischemia time, which is measured from the time of removal of donor liver from ice until reperfusion. Sub-analysis of individual resuscitation components demonstrated significantly less cell saver return, FFP, and platelets, and overall resuscitation volume in the piggyback technique.

Mean preoperative hemoglobin, coagulation parameters (INR, PTT, fibrinogen), and renal function (blood urea nitrogen, creatinine) were equal between groups with exception to the preoperative hemoglobin, though all groups went into their operations with a mean hemoglobin of greater than 100 g/L. Patients were resuscitated to the same endpoints as measured by postoperative lab values upon first arrival to the intensive care unit. There was no difference in hemoglobin, coagulation parameters, renal function, or acidosis as indicated by pH and lactate.

Clinical and vascular outcomes are summarized in Table 3. The frequency of cardiac arrest at reperfusion was 3%. There was no difference in length of stay or mortality outcomes. Overall rate of clinical and vascular complications within each group was low and precludes statistical comparison.