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ScienceDirect

EJSO the Journal of Cancer Surgery

EJSO xx (2016) 1–6 www.ejso.com

A retrospective analysis of liver resection performed without central venous pressure monitoring

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Accepted 22 March 2016
Available online ■ ■ ■

Abstract

Background: Studies have suggested that blood loss can be reduced during liver resection by monitoring and maintaining low central venous pressure (CVP) through fluid restriction or other means, but such a strategy carries risks to the patient including those inherent to central venous catheterization. We sought to characterize fluid management and blood loss during liver resections done without CVP monitoring.
Methods: Retrospective data were extracted from electronic anesthesia records for 993 liver resections. For 135 resections, between 2011 through 2013, where a documentation template was used that recorded fluid administration prior to hepatic inflow occlusion, multivariate analysis was performed to test for an association between pre-clamp fluid volumes administered and blood loss and other adverse outcomes.
Results: The median estimated blood loss was 300 mL and overall rate of transfusion was 8.6%. There was no statistically significant association between crystalloid volume administered prior to inflow clamping (median 900 mL) and blood loss, mortality or length of stay in the subset of patients with supplemental fluid data.
Conclusion: Liver resection can be performed safely without either CVP monitoring or non-invasive continuous cardiac output monitoring. Additionally, there was no disadvantage to a practical approach to fluid administration prior to inflow clamping during liver resections in the absence of CVP monitoring with regard to blood loss or short-term outcomes.

Keywords: Hepatectomy; Liver resection; Fluid management

Introduction

Liver resection is the treatment of choice for many primary liver cancers and hepatic metastases, but carries with it the possibility of substantial blood loss and need for blood transfusion. Blood product administration is fraught with risks[1] and, in cases performed for malignancy, has been associated with tumor recurrence and increased mortality.[2–4] Therefore, anesthesiologists and surgeons seek to limit blood loss during liver resection.

While surgical techniques such as hepatic inflow occlusion (i.e., Pringle maneuver) may be helpful, reduced blood loss can also reportedly be achieved by maintaining low central venous pressure (CVP).[5–8] This strategy may decrease pressure in hepatic veins during parenchymal resection and thereby decrease bleeding.[9–14] Not surprisingly, a multi-national survey showed that 85% of centers

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http://dx.doi.org/10.1016/j.ejso.2016.03.025
0748-7983/

used intraoperative fluid restriction to reduce central venous pressure (though the frequency of CVP monitoring was not reported).[15]

A low CVP strategy traditionally requires placement of a central venous catheter (or possibly peripheral catheter) for CVP measurement.[16–18] However, CVP is an imprecise measure of central pressure and fluid responsiveness[19,20] and some centers may choose to forego CVP monitoring in order to avoid the risks inherent to central venous catheterization, such as risk of infection, pneumothorax, hemothorax, arterial puncture and added cost.[21,22] Fluid restriction itself may also increase the risk of venous air embolism or renal dysfunction, in general. At the authors' institution, routine CVP monitoring has not been used during major hepatic resection for over a decade. Also, our group has not universally employed strict fluid restriction during this period. Instead, we have employed a practical, relative fluid restriction strategy in which our fluid management is guided by maintaining an adequate urine output ($>$0.5 cc/kg/hr) while attempting to maintain a MAP $>$ 65 mmHg and utilizing arterial waveform analysis. We attempted to determine if there was an association between this strategy and intraoperative blood loss and other adverse short-term outcomes.

Methods

Electronic records from an anesthesia information management system were screened to find adult patients who had undergone open liver resection at the authors' tertiary, high volume center from 01/2002 to 12/2013 without CVP monitoring. Data were extracted from the anesthesia records as well as from a clinical database after institutional review board approval (Program for the Protection of Human Subjects, Mount Sinai School of Medicine, New York, NY) and waiver of consent for the retrospective study.

The surgical methodology that we employ has been previously published by our group.[11,23,24,34] Inclusion criteria for resection required Child's A or better liver function, presence of a single tumor on imaging study without extrahepatic spread, and absence of portal hypertension. Portal hypertension was defined by the presence of varices on imaging study/endoscopy, splenomegaly with a platelet count of less than 100×10^9/L, or hepatic venous pressure gradient of $>$10 mm Hg. Macrovascular invasion was defined as tumor within vascular branches identified on preoperative imaging or evident on gross examination of the surgical specimen. Major hepatectomy was defined as resection of $\geq$3 Couinaud liver segments. In select patients with borderline hepatic reserve, preoperative portal vein embolization was used when major resection was expected. Parenchymal transection was performed using Pringle maneuver and a crush technique with Metzenbaum scissor and hemostatic clips.[25] In addition, techniques for transection requiring no inflow control, including ultrasonic dissection and energy-based sealing systems, were occasionally employed. We favored anatomic resection when feasible respecting all oncologic principles.

As part of our group's approach to management, central line placement was reserved for cases where extraordinary fluid shifts were anticipated, the need for long term vasoactive infusions was anticipated, or adequate peripheral access could not be obtained. Cases in which total caval isolation was employed were excluded as these cases generally had central venous line placement as a part of management. There was no strict protocol for intraoperative IV fluid management, instead a pragmatic approach to fluid administration was attempted. No patients underwent a bowel prep or neoadjuvant therapy prior to the procedure.

Documentation in cases from 01/2011 through 12/2013 utilized a special departmental template that allowed for recording of total IV fluid administration (IVF) and estimated blood loss (EBL) prior to porta hepatis clamping, in addition to standard documentation of total IVF and EBL at the end of the case. Cases performed over this period of time that did not employ hepatic inflow occlusion were not included in the pre-parenchymal fluid administration template analysis. All retrospective data were retrieved from the original prospectively maintained database. The majority of the procedures were performed by two of the hepatobiliary surgeons. Preoperative variables included age, gender, preoperative laboratory values, and evidence of portal hypertension. Further variables included number of resected segments, estimated blood loss, operative time, need for transfusion, number of units transfused, and presence of inflow occlusion. Pathological variables included presence of severe fibrosis (Scheuer fibrosis stage 3, 4), largest tumor diameter, tumor differentiation, presence of vascular invasion and satellite nodules, and positive margin. Postoperative variables included routine laboratory values upon discharge as well need for postoperative transfusion.

For the entire dataset, descriptive statistics were generated. For the subset of cases with supplemental documentation, multivariate analysis was performed. The primary outcome variable was post-clamp EBL as it relates to pre-clamp IVF administration. Secondary outcomes were defined as in-hospital mortality or length-of stay over 90th percentile among survivors. Logistic regression analysis was performed to test for the association between pre-clamp IVF and adverse outcomes while controlling for pre-clamp EBL. As a sensitivity analysis, forward stepwise selection method with entry and stay criteria both of 0.05 was used to allow inclusion of other significant covariates in the model (e.g. age, gender, weight, start hour of the case, pre-clamp EBL, and inpatient vs. day-of-surgery admission status). Because the distribution of post-clamp EBL was highly skewed, rank-based linear regression analysis was used to determine if there was an association between pre-clamp IVF and the rank of post-clamp EBL

Please cite this article in press as: Wax DB, et al., A retrospective analysis of liver resection performed without central venous pressure monitoring, Eur J Surg Oncol (2016), http://dx.doi.org/10.1016/j.ejso.2016.03.025