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ORIGINAL ARTICLE

Renal function after low central venous pressure-assisted liver resection: assessment of 2116 cases

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Abstract

Objectives: Low central venous pressure (LCVP)-assisted hepatectomy is associated with decreased blood loss and lower transfusion rates. Concerns about its impact on renal function have prevented widespread application. This study was conducted to review the dynamics of renal function after LCVP-assisted hepatectomy.

Methods: A retrospective analysis of a prospective surgical database was carried out. Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) equation. The RIFLE (*r*isk–*i*njury–*f*ailure–*l*oss–*e*nd-stage) criteria were used to define postoperative biochemical acute kidney injury (bAKI). Occurrences of clinically relevant AKI (cAKI) were identified in the study center postoperative database.

Results: During the period 2003–2012, 2116 LCVP-assisted hepatectomies were performed. The median patient age was 61 years [interquartile range (IQR): 51–70 years] and 51% of patients were male. The median number of resected segments was two; resections involved from one to four segments. Median estimated blood loss was 300 ml (IQR: 200–600 ml). Rates of morbidity and 90-day mortality were 21% and 2%, respectively. Low baseline eGFR (<90 ml/min) was seen in 84% of patients; 29% of patients had eGFR of <30 ml/min. Postoperative bAKI was seen in 17% (n = 350) of patients. Biochemical AKI with low eGFR was seen in 336 patients, representing 16% of the whole cohort; 13% of patients had been at risk, 2% experienced injury and 1% experienced failure. Kidney function had normalized at discharge in 159 of these patients. Nine patients (<1%) developed postoperative cAKI.

Conclusions: The majority of patients in the study cohort had low baseline eGFR. Biochemical alterations in eGFR are transient in the vast majority of patients after LCVP-assisted hepatectomy and their clinical impact is limited. The present data suggest that clinically relevant renal dysfunction is a very uncommon event in patients undergoing LCVP-assisted liver resection.

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Introduction

Low central venous pressure (LCVP)-assisted liver resection has been practiced at the Memorial Sloan–Kettering Cancer Center (MSKCC) for two decades.[1,2] This technique, which requires close collaboration between the surgical and anesthesia teams, has proven to be safe and reproducible, and to be of value in reducing the amount of blood loss during hepatic resection. Before routine application of LCVP, operative haemorrhage during liver resection commonly led to prohibitively high morbidity and mortality rates.[3–6] In addition to the morbidity and mortality associated with hypovolaemia and shock, deleterious effects in postoperative morbidity and longterm oncologic outcomes have been shown in patients receiving blood transfusions after liver resection.[7–10]

Although this technique has been shown to be safe and effective in reducing operative blood loss in several studies evaluating liver resection and transplantation,[11–15] its widespread application is still limited. Concerns have been raised about the potential for morbidity that may derive from the hypoperfusion of abdominal organs during the LCVP phase of liver resection. Specifically, the impact that the relative hypotension and potential hypoperfusion may have on kidney function have been cited as limiting factors as there is a theoretical risk for prerenal acute renal failure such as that seen in other types of operations in which splanchnic and renal circulation may be compromised.[16]

The present study was conducted with the aim of evaluating renal function in a large, recent cohort of patients submitted to liver resection at a single institution at which the use of LCVP-assisted liver resection is routine in order to update this center's previously published experience.[2] This paper reports postoperative outcomes and evaluates renal function according to current classification systems based on serum creatinine and eGFR. Postoperative renal function was evaluated based on biochemical and clinical criteria and its relationship with preoperative, operative and postoperative outcomes is appraised.

Materials and methods

Institutional review board approval was obtained. The study center's institutional prospective hepatobiliary database was queried for patients submitted to liver resection under LCVP. Demographic, operative and postoperative variables were extracted. In this center's database, major liver resection is defined as resection of three or more segments according to the Couinaud classification.[17] Morbidity was extracted from the MSKCC Secondary Events Program database. To populate this database, cases were prospectively reviewed and complications recorded and graded in severity in a standardized fashion.[18] Data were pooled in a Microsoft Access database. Standard descriptive statistics were applied. Continuous data are summarized and reported as the median and interquartile range (IQR) unless otherwise specified; these variables were compared using *t*-tests or the Wilcoxon rank-sum test depending on the distribution. Categorical data are presented as the total number and percentage and compared using the chi-squared or Fisher's exact test depending on the number of events. A *P*-value of <0.05 was considered to indicate statistical significance. All statistical analyses were performed using STATA Version 12.1 (StataCorp LP, College Station, TX, USA).

The MSKCC clinical laboratory database was queried to extract all laboratory results in the present patient population starting from preoperative baseline until postoperative day (POD) 14 or discharge, whichever occurred first. Glomerular filtration rate was estimated (eGFR) using the Modification of Diet in Renal Disease (MDRD) equation:

$$\text{eGFR} = 175 \times \text{SerumCr} - 1.154 * \text{age} - 0.203 * 1.212 \\ \text{(if patient is black)} * 0.742 \text{ (if female)}$$ [19]

Chronic kidney disease (CKD) was evaluated based on the eGFR and classified according to the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI), which measures renal function as a measure of eGFR and classifies it into stages.[20] An eGFR of ≥90 ml/min is considered normal. Subsequent interval reductions are classified as mild dysfunction (stage 2, eGFR: 60–89 ml/min), moderate dysfunction (stage 3, eGFR: 30–59 ml/min), severe dysfunction (stage 4, eGFR: 15–29 ml/min) and kidney failure (stage 5, eGFR: <15 ml/min). The degree of renal dysfunction was evaluated at baseline, at its lowest level postoperatively, and on POD 14 or at discharge. For patients who were discharged with an abnormal eGFR, creatinine levels measured at follow-up were retrieved whenever possible to evaluate for the resolution of renal dysfunction.

Furthermore, the Acute Dialysis Quality Initiative (ADQI) guidelines for the definition of acute renal failure in critically ill patients were used to evaluate the incidence of postoperative biochemical acute kidney injury (AKI) (bAKI) in this population.[21] These guidelines were used to develop the RIFLE (*r*isk–*i*njury–*f*ailure–*l*oss–*e*nd-stage) classification, which defines AKI based on the percentage change in eGFR from baseline in response to an insult and stratifies patients based on the magnitude of this change. Patients with a decrease of >25% in eGFR are considered at risk of renal dysfunction; a decrease in eGFR of >50% denotes kidney injury, and a decrease in eGFR of >75% indicates kidney failure. Loss of function and end-stage disease represent the complete loss of kidney function for >4 weeks and the presence of end-stage kidney disease (>3 months), respectively. The incidence of clinically relevant AKI was estimated from the MSKCC prospective morbidity database and graded in levels of severity. Clinical AKI (cAKI) was defined as oliguria accompanied by elevated creatinine levels.

This center's anesthetic approach to LCVP-assisted liver resection has been previously published.[1,2] Intraoperative fluid management is divided into two phases. Prehepatic resection starts at the induction of anesthesia and ends at the completion of parenchymal transection and haemostasis. During this phase, inflow control of the portal vein and hepatic artery is achieved and the vena cava and hepatic veins are dissected. Hepatic parenchymal transection is performed, during which intermittent inflow occlusion is applied (Pringle manoeuvre). This phase takes advantage of fluid restriction and the vasodilatory effects of anesthetic drugs to provide LCVP. Fluid boluses and/or vasoactive drugs are administered at the discretion of the anesthesia care team to maintain systolic blood pressure (SBP) of ≥90 mmHg and urine output of >25 ml/h while maintaining the CVP at <5 mmHg. The use of central venous catheters to provide LCVP-assisted liver resection has been abandoned in this center. If visual inspection shows the retrohepatic vena cava not to have collapsed to the surgeon's satisfaction, sublingual nitroglycerine