ORIGINAL ARTICLE

Intraoperative monitoring of stroke volume variation versus central venous pressure in laparoscopic liver surgery: a randomized prospective comparative trial

Francesca Ratti[1], Federica Cipriani[1], Raffaella Reineke[2], Marco Catena[1], Michele Paganelli[1], Laura Comotti[2], Luigi Beretta[2] & Luca Aldrighetti[1]

[1]Division of Hepatobiliary Surgery, and [2]Department of Anaesthesiology and Intensive Care, IRCCS San Raffaele Hospital, Milano, Italy

Abstract

Background: Central venous pressure (CVP) is used as a marker of cardiac preload to control intraoperative blood loss in open hepatectomies, while its reliability in laparoscopy is less certain. The aim of this randomized prospective trial was to evaluate the outcome of laparoscopic resections performed with stroke volume variation (SVV) or CVP monitoring.

Methods: All candidates for laparoscopic liver resection were assigned randomly to SVV or to CVP groups. Outcome was evaluated included conversion rate, cause of conversion, intraoperative blood loss, need for transfusions, length of surgery and postoperative results.

Results: Ninety consecutive patients were enrolled: both SVV and CVP groups included 45 patients each and were comparable in terms of patient and disease characteristics. A reduced rate of conversion was recorded in the SVV compared to the CVP group (6.7% and 17.8% respectively, p = 0.02). Blood loss was lower in the SVV group (150 mL), compared to the CVP group (300 mL, p = 0.04). Morbidity, mortality, length of stay and functional recovery were comparable. On multivariate analysis, lesion location, extent of hepatectomy and type of cardiac preload monitoring were associated significantly to risk of conversion.

Conclusion: SVV monitoring in laparoscopic liver surgery improves intraoperative outcome, thus enhancing the benefits of the minimally-invasive approach and fast-track protocols.

Received 15 September 2015; accepted 22 September 2015

Correspondence

Francesca Ratti, IRCCS San Raffaele Hospital, Via Olgettina 60, 20132 Milano.
Tel: +39 02 26437811/7808, +39 348 2411961. Fax: +39 02 26437807. E-mail: ratti.francesca@hsr.it

Introduction

The minimally-invasive approach for liver resections has experienced a widespread diffusion worldwide,[1–3] given its benefits in terms of perioperative outcomes and in spite of oncological results similar to those of open surgery.[4–6] In particular, many comparative series have reported reduced blood loss and transfusions requirements in patients scheduled for laparoscopy.[7–9]

Despite this, bleeding is still reported as the leading cause of conversion in most series.[2,6,7,9,10] A correlation between blood loss and clinical outcomes has been demonstrated, with impact on both morbidity and mortality rates as well as disease recurrence and survival rates.[11,12] In this setting, any effort to improve bleeding control and to reduce the need for blood transfusions is of key importance. In laparoscopy, the haemostatic effect of the pneumoperitoneum and image magnification contributes to obtain a more accurate haemostasis.[3,7] On the other hand, portal triad clamping is an effective method to control intraoperative bleeding and can be adopted even in laparoscopic hepatectomies.[2,13]

Disclosure: The authors of this manuscript have no conflicts of interest to disclose and further disclose any commercial interest that they may have in the subject of study and the source of any financial or material support.

Abbreviations

SVV	stroke volume variation
CVP	central venous pressure
CVC	central venous catheter
LLR	laparoscopic liver resection

Many reports have shown that the reduction of cardiac preload results in a significant reduction of blood loss, thus decreasing hepatic veins congestion.[14,15] Historically, central venous pressure (CVP) has always been used to measure preload in open surgery.[14,15] More recently, the accuracy of stroke volume variation (SVV) has been reported to guide fluid management.[16] The SVV can be measured non-invasively through the FloTrac Vigileo system and its correlation with patient's volaemic status is excellent.[17,18]

Patient positioning[19] and pneumoperitoneum influence CVP, may result in unreliable values and may not guide intraoperative fluid management in maintaining patients in an hypovolaemic state, which is still of primary importance in liver surgery, even with laparoscopic approach.

The aim of the present study was to evaluate the role of SVV monitoring in laparoscopic hepatic surgery compared with CVP and to analyse its implications on short-term outcome. The primary endpoint was to assess conversion rate, while secondary endpoints were to record intra- and postoperative outcomes.

Methods

Study design

From April 2012 to October 2014, all candidates for laparoscopic liver resection (LLR) for primary or secondary liver tumours at the Hepatobiliary surgery Division of San Raffaele Hospital, Milano were screened for enrolment in this prospective randomized study. Patients who met one or more of the following criteria were excluded: associated major abdominal procedures (e.g. colorectal and/or pancreatic resections); repeated liver resections; single-port resections; patients under 18 years of age or unable to give their informed consent. Eligible patients were randomly assigned to a treatment arm: patients in the study group (SVV group) underwent intraoperative monitoring of SVV via FloTrac Vigileo system, while patients in the control group (CVP group) underwent intraoperative monitoring of CVP via central venous catheter (CVC). The anaesthetic and surgical teams were the same for all patients. Treatment allocation was open to both the anaesthesiologists (RR, LC, LB) and the surgeons (LA, MP, MC), while it was blinded to principal investigator (FR) who was responsible for data recording. Randomization was performed using the randomization function of Excel (Windows Office package) and block randomization.

The study protocol was designed according to European Ethical Standards and was approved by the medical ethical committee of our institution and all patients provided written informed consent before preoperative assessment.

Anaesthesia and volaemic status monitoring

General anaesthesia was performed in a standardized way, administering for induction intravenous fentanyl (2 mcg/kg) and propofol (2 mg/kg). Muscle relaxation was obtained with a bolus of non-depolarizing curare (cisatracurium or rocuronium at a dose of 0.5 mg/kg or 0.6 mg/kg respectively). All patients were mechanically ventilated with a tidal volume of 8 mL/kg without PEEP. Anaesthesia was maintained with inhaled halogenated gas (sevoflorane or desflorane titrated to minimal alveolar concentration). In all patients ECG (electrocardiogram) and MAP (mean arterial blood pressure) were obtained using a radial or humeral catheterization, pulse oxymetry and diuresis were monitored.[20] In the SVV group, arterial access was connected to the FloTrac sensor of the Vigileo monitor system (Edwards Lifesciences) to measure SVV. In this group SV (stroke volume), CO (cardiac output) and CI (cardiac index) were monitored; VO_2 (oxygen consumption) and DO_2 (oxygen delivery) were calculated on the basis of blood gas analysis which was repeated during surgery in both groups to check either the onset of acidosis or the level of haemoglobin.[21] In the SVV group, the goal was to maintain SVV over 12% (at least among 12–15%) during resection. In the CVP group, CVP was measured through a CVC inserted in the internal jugular vein after the induction of general anaesthesia. In this group SvO_2 (oxygen venous saturation) was monitored as well. The goal was to maintain CVP under or equal to 5 cm H20. Hence, fluid therapy with crystalloids was guided by SVV or CVP values to achieve an hypovolaemic state. Whenever the simply restriction of fluid administration was not sufficient to guarantee hypovolaemia, a diuretic (furosemide 5–10 mg i.v.) was administered. Low MAP (<50 mmHg) was an indication for fluids administration, while tachycardia was not. No patient received vasopressors to maintain mean arterial pressure above 50 mmHg or to correct any oxygen debt due to cardiac failure.

Perioperative management of patients was conducted following the principles of fast-track protocol in liver surgery.[22]

Surgery

For laparoscopic resections the patient was placed in the "French" position with the first surgeon standing between the patient's legs and assistants on each side. Whenever possible, a four trocar configuration was used. The liver was examined by direct vision and intraoperative ultrasonography and the line of intended resection marked on its surface using diathermy. Hepatic transection was performed using the SonoSurg system (Olympus, Tokyo, Japan), which integrates an ultrasonic

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