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ORIGINAL ARTICLE

Evaluation of pleth variability index as a predictor of fluid responsiveness during orthotopic liver transplantation

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Abstract Fluid management is challenging and still remains controversial in orthotopic liver transplantation (OLT). The pleth variability index (PVI) has been shown to be a reliable predictor of fluid responsiveness of perioperative and critically ill patients; however, it has not been evaluated in OLT. This study was designed to examine whether the PVI can reliably predict fluid responsiveness in OLT and to compare PVI with other hemodynamic indexes that are measured using the $PiCCO_2$ monitoring system. Twenty-five patients were enrolled in this study. Each patient was monitored using the noninvasive Masimo and $PiCCO_2$ monitoring system. PVI was obtained with a Masimo pulse oximeter. Cardiac index was obtained using a transpulmonary thermodilution technique (CI_{TPTD}). Stroke volume variation (SVV), pulse pressure variation, and systemic vascular resistance index were measured using the $PiCCO_2$ system. Fluid loading (10 mL/kg colloid) was performed at two different phases during the operation, and fluid responsiveness was defined as an increase in $CI_{TPTD} \geq 15\%$. During the dissection phase and the anhepatic phase, respectively, 14 patients (56%) and 18 patients (75%) were classified as responders. There were no differences between the baseline values of the PVI of responders and nonresponders. Area under the curve for PVI was 0.56 (sensitivity 35%, specificity 90%, $p = 0.58$) at dissection phase, and was 0.55 (sensitivity 55%, specificity 66%, $p = 0.58$) at

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anhepatic phase. Of the parameters, a higher area under the curve value was found for SVV. We conclude that PVI was unable to predict fluid responsiveness with sufficient accuracy in patients undergoing OLT, but the SVV parameter was reliable.

Introduction

Hyperdynamic circulation due to high cardiac output (CO), low systemic vascular resistance, and relative hypovolemia occur in cirrhotic patients undergoing orthotopic liver transplantation (OLT) [1,2]. The patients encounter major cardiovascular changes during OLT as a consequence of surgical bleeding, vena cava cross clamping, and reperfusion. The fluid management of these patients is very challenging and still remains controversial; however, it is important to avoid fluid overloading and to supply sufficient perfusion to the graft [3].

The concept of fluid responsiveness has been increasingly used to optimize fluid management. Static variables of the cardiac preload, such as central venous pressure (CVP) and pulmonary artery occlusion pressure, are reported as unreliable for evaluating fluid responsiveness [4–7]. It has been suggested that the dynamic indicators measured depend on the respiratory variation of stroke volume estimated using pulse contour analysis of patients receiving mechanical ventilation and the pulse pressure variations obtained from the arterial pulse pressure are superior to the static indicators [7,8]. However, these techniques are either invasive with potential complications or are not constant [7]. Recently, several investigators have focused on noninvasive indicators such as the plethysmographic variability index and the variation of the plethysmographic waveform of pulse oximetry, which have strong relationships with respiratory variations in arterial pulse pressure [9,10].

The Masimo pulse oximeter incorporates an algorithm to continuously measure the changes in pulse volume (PVI) and uses a pulse oximetry probe that is very similar to an ordinary one. The PVI measures the dynamic changes of the perfusion index (PI) over respiratory cycles and is calculated as follows:

$$PVI = [(PI\ maximum - PI\ minimum)/PI\ maximum] \times 100\% \quad (1)$$

[7,11].

The PVI is presented as a safe and useful parameter for evaluating fluid responsiveness of perioperative patients who underwent major abdominal surgery and for critically ill patients [11–15]. However, the accuracy of the PVI is unclear for OLT operations that have hyperdynamic circulation and major cardiovascular changes.

The aims of this study were to evaluate the efficiency of the PVI to predict fluid responsiveness at different surgical phases of OLT and to compare the PVI with other indicators of fluid responsiveness that were measured using the $PiCCO_2$ monitoring system.

Methods

After approval of the study protocol by the Inonu University Medical Faculty Ethics Committee, Malatya, Turkey (Number: 2011/204), signed written informed consent was obtained from the patients' or the relatives of the patient. Twenty-five patients, older than 18 years and undergoing OLT, were included in the study. Patients were excluded from the study if they presented with cardiac arrhythmias, low left ventricular function (ejection fraction $< 40\%$), renal dysfunction, valvular heart disease, pulmonary hypertension, or fulminant hepatic failure. The demographic data, the Child (Child–Turcotte–Pugh) scores and the Model for End Stage Liver Disease scores of the patients were recorded.

Anesthetic method

Unpremedicated patients were brought into the operating room and were monitored using three-lead electrocardiography, pulse oximetry, noninvasive blood pressure, and bispectral index. Anesthetic induction was performed with 3–5 mg/kg thiopental, 1–2 μg/kg fentanyl, and 0.15 mg/kg cisatracurium besylate. Anesthesia was maintained with an infusion of 0.1–0.2 μg/kg/min remifentanil, 0.1 mg/kg/h cisatracurium besylate, and with 0.4–1% isoflurane in 40% oxygen/air. The bispectral index level was protected between 40 and 60 throughout the surgery. The ventilator settings were standardized with volume-controlled mode (tidal volume of 8 mL/kg, zero end-expiratory pressure, and respiratory rate was adjusted to maintain end-tidal carbon dioxide levels within 30–40 mmHg) following the intubation.

To prevent hypothermia, warming blankets were used, and intravenously administered fluids were warmed (Hot Line SIMS Medical System Inc., Rockland, MA, USA; Fluido Pressure Chamber, TSCI, Amersfoort, The Netherlands). Patients were given Isolyte S® (Eczacıbaşı-baxter, Istanbul, Turkey) and 6% hydroxyethyl starch for intravascular volume replacement, and 20% human albumin was administered in cases of hypoalbuminemia (albumin < 2.5 g/dL). Fresh frozen plasma was given depending on the prothrombin time (to maintain the international normalized ratio between 1.5 and 2.0) and thrombocyte suspension was given if the thrombocyte count was lower than 50,000/mm^3. An erythrocyte suspension was transfused based on the hemoglobin concentration (transfused if hemoglobin $<$ 7 g/dL). Mannitol and/or furosemide were used when needed to sustain a mean rate of urination of > 1 mL/kg/h. Norepinephrine, dopamine, or epinephrine infusions were administered when the mean arterial pressure was lower