Corrected Flow Time Is a Good Indicator for Preload Responsiveness During Living Donor Liver Donation

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ABSTRACT

Background. Corrected flow time (FTc) has been utilized as preload indicator in recent literature. Accurate estimation of preload status during living donor liver donation (LDLD) is important due to fluid restriction. We evaluate the effectiveness of FTc as a surrogate of preload indicator during LDLD.

Materials and Methods. Twenty-five patients undergoing LDLD were enrolled in the study. Administration of intravenous fluid was restricted before lobectomy was performed. After the organ was harvested, fluid challenge with 500 mL of Voluven (130/0.42, Fresenius, Friedberg, Germany) was performed. Stroke volume (SV) was measured with ultrasonic cardiac output monitor (USCOM; USCOM Pty, Ltd, Sydney, Australia) before and after the fluid challenge. The FTc value obtained with USCOM before fluid challenge was recorded. Fluid responsiveness was defined as an increase in SV of more than 15%. Receiver operating characteristic (ROC) curve was performed.

Results. The area under ROC curve was 0.9. The optimal cutoff FTc value was 340 milliseconds during LDLD.

Conclusions. FTc is a noninvasive, easily obtainable, and essentially good preload indicator during LDLD.

Modern hepatic resection is often performed under low central venous pressure (CVP) anesthesia (ie, fluid restriction technique) [1–3]. However, fluid restriction is not without its risks, such as increased risks of renal dysfunction and inability to respond to sudden blood loss during major hepatic resection. Monitoring preload status during hepatic resection, especially under fluid restriction, is important. Traditional pressure-based preload indices, such as CVP and pulmonary artery occlusive pressure (PAOP), have several shortcomings and have been replaced with newer preload dynamic indices [4–6]. Corrected flow time (FTc) measured with ultrasound is a new method to monitor preload status and has been tested in ventilated patients [7] and neurosurgical patients [8]. This study tested the ability of FTc in predicting fluid responsiveness during fluid-restricted living donor liver donation (LDLD) surgery.

Materials and Methods

The study was approved by the institutional ethics committee and was performed between July 2012 and August 2013. Written informed consent was obtained from all participants. Twenty-five patients scheduled for LDLD were enrolled. Patients with arrhythmia, severe peripheral vascular disease, or valvular dysfunction were excluded.

Perioperative Management

Standard institutional protocol for anesthetic procedure was followed. Fentanyl, propofol, and cisatracurium were administered for induction of anesthesia on a dose-per-weight basis. The patient was put on volume-controlled mechanical ventilation after intubation with a tidal volume of at least 8 mL/kg ideal body weight. Anesthesia was maintained with an oxygen-air-sevofoflurane mixture.
and intermittent cisatracurium bolus administration for continuing muscle relaxation. No changes in monitoring or anesthetic management were required from previously established protocols in our institution. Fluid was restricted from the night before the surgery, with the total amount of fluid restricted to <300 mL before hepatectomy was accomplished. Either right- or left-side hepatectomy was performed according to the surgeon’s preoperative planning, and 500 mL of 6% 130/0.4 hydroxyethyl starch (HES) solutions (Voluven, Fresenius Kabi, Friedberg, Germany) solution (Voluven, Fresenius) was quickly infused after the hepatectomy.

Hemodynamic Parameter Measurement

FTc measurement by ultrasonic cardiac output (CO) monitor (USCOM; USCOM Pty, Ltd, Sydney, Australia) was recorded before fluid challenge. CO was measured before and after the HES solution challenge was performed. A CO increase of more than 15% after the fluid challenge was defined as “fluid responsiveness” [9]. All measurements were performed through the suprasternal insonation window with visual examination of the ejection waveform to confirm accurate targeting of the aortic valve. The reading was accepted if the flow profile was of diagnostic quality with the flow being clear in its commencement and cessation, with a well-defined image base and peak and without acoustic interference [10,11]. At least 3 diagnostic-quality images obtained at the end expiratory phase of the respiratory cycle were selected for estimation of CO. All USCOM measurements were performed by the same operator.

Statistics

Statistical analysis was performed with MedCalc software, version 12.4.0.0 (MedCalc Inc, Mariakerke, Belgium) for basic parameter and area under receiver operating characteristic curve (AUC) measurement [12,13]. The ability of FTc in predicting preload responsiveness was assessed with AUC with no, little, acceptable, excellent, and outstanding discrimination being defines as AUC < 0.5, 0.5 ≤ AUC < 0.7, 0.7 ≤ AUC < 0.8, 0.8 ≤ AUC < 0.9, and AUC ≥ 0.9, respectively.

RESULTS

Twenty-five patients undergoing LDLD were enrolled in the study. The area under receiver operating characteristic (ROC) curve was 0.9 (Fig 1). The optimal cutoff FTc value in predicting fluid responsiveness was 340 milliseconds during LDLD.

DISCUSSION

This study shows that FTc measured with USCOM monitor is a good indicator of fluid responsiveness during fluid-restricted hepatectomy.

Traditional static hemodynamic monitors such as CVP and PAOP have been long regarded as indicators of preload status. CVP is routinely used in guiding fluid therapy, affecting the establishment of several well-known clinical guidelines, such as the low CVP strategy during hepatectomy. However, recent evidence suggests that the absolute values of these static parameters are inaccurate and that the relative changes (ie, trending) are not sensitive in guiding fluid therapy in critically ill patients [4–6].

The differences of preload indicator and preload responsiveness indicator can be explained through the Frank-Starling law. The stroke volume (SV) increase through fluid challenge may differ at various inotropic statuses (ie, different Frank-Starling curves). Preload responsiveness simply predicts whether the SV will respond to a fluid challenge, which is a combination of x- and y-axis. In contrast, preload status indicated by static parameter stands only for the y-axis. As it is difficult to predict which Frank-Starling curve the patient lies on, considering preload responsiveness to guide fluid therapy seems more rational and practical.

Several parameters are regarded as preload responsiveness-specific indicators [13–16]. Most of them are respiratory-based dynamic indices. During inspiration phases of mechanical ventilation, the positive intrathoracic pressure increases left ventricle preload, which leads to an acute SV increase in the left ventricle. At the same time, such positive pressure also decreases the preload status and increases the afterload of the right ventricle, leading to acetely diminished SV in the right ventricle. As the heart is a contiguous two-sided pump, such a decrease in SV in the right ventricle will lead to a decrease in SV in the left ventricle after the pulmonary transit time. The difference between maximum and minimum of SV during different mechanical ventilation phases then leads to SV variation (SVV). Respiratory-based dynamic indices, such as SVV [13,14], pulse pressure variation [13], systolic pressure variation, and even pleth variability index [16], all originate from the previous cardiopulmonary interaction. If the patient is more dehydrated, the value of the dynamic indices will be greater. Previous reports showed great fluid responsiveness
predictability of all dynamic indices with an AUC of greater than 0.9 under well-controlled clinical environments [13,16].

Despite the usefulness of respiratory-based dynamic indices, these parameters have several limitations [17,18]. First, the patient must be fully mechanically ventilated without any spontaneous breathing. Second, the tidal volume should be more than 7 mL/kg. Third, several clinical conditions, such as arrhythmia, severe pulmonary disease, right ventricle failure, or pulmonary hypertension, preclude the use of these parameters. On the contrary, FTc is a ventilation-independent parameter. It will not be affected by arrhythmia or other cardiopulmonary status. Its clinical use is greater than dynamic indices. According to our study, FTc less than 340 milliseconds is a good indicator for volume responsive. This is compatible with the cutoff value of FTc from the previous literature, which lies between 330 and 350 milliseconds [7,8,19–21].

There are several limitations to our study. First, the use of USCOM requires technique. Searching for the optimal signal is required for accurate estimation of CO, which may have led to error in our study. However, our institute is experienced in operating USCOM. Second, the study was performed under a well-controlled environment. None of the patients were arrhythmic. All of the patients were under mechanical ventilation during the measurement of FTc. Our results can only then be applied to mechanical ventilated and nonarrhythmic patients. Last, considering the “gray zone” concept used in dynamic indices, it would be logical that there should be a gray zone in FTc predicting preload responsiveness.

In conclusion, FTc measured with USCOM can reliably predict fluid responsiveness during a fluid-restricted hepatectomy. Its further application during surgery and in other patients merits further study.

REFERENCES