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Assessment of hemodynamic response to fluid resuscitation of patients with intra-abdominal sepsis in low- and middle-income countries

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ABSTRACT

Background: Patients with intra-abdominal infections need to achieve adequate hemodynamic status before being taken to the operating room. Multiple parameters (urinary output [UOP], vital signs, inferior vena cava collapsibility index, and central venous pressure) may be used to assess hemodynamic response to fluid resuscitation, but the options are few in limited-resource settings. This study aimed at assessing if a bedside-performed ultrasound to assess the inferior vena cava collapsibility index is superior to UOP in assessing hemodynamic response to fluid resuscitation.

Methods: All adult patients presenting to a tertiary referral hospital in the capital city of Rwanda with intra-abdominal infection requiring intravenous fluid (IVF) resuscitation before operation were included in this study. Before IVF administration, the baseline inferior vena cava collapsibility index (IVC-CI) and vital parameters were recorded. After initiation of IVF resuscitation, serial measurements of IVC-CI and UOP were recorded every 2 h until the decision was made to take the patient to the operating room.

Results: Twenty-four patients were enrolled. The mean duration of symptoms was 4.7 days. Four patients (16%) had altered mental status as a presenting symptom. Half of all patients had generalized peritonitis due to gangrenous bowel as the primary diagnosis ($n = 12$). The mean difference between time of hemodynamic response based on IVC-CI *versus* UOP was 2 h ($P < 0.001$).

Conclusions: Measurement of the IVC-CI can provide early detection of hemodynamic response to fluid therapy in patients with intra-abdominal infection with spontaneous breathing compared to UOP. Future research should utilize this parameter in the preoperative management of hemodynamically unstable patients.

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Introduction

The management of severe sepsis and septic shock includes intravenous fluid (IVF) resuscitation, intravenous broad spectrum antibiotics, and source control of the infection. Fluid resuscitation is important for cardiovascular support in patients with severe sepsis, and it should be started as early as possible.[1,2] Intravenous volume expansion with crystalloids is required before laparotomy for peritonitis.[3]

Both under resuscitation or over resuscitation of patients with severe sepsis or septic shock can have adverse effects.[4,5] Fluid overload increases the risk of postoperative complications, such as acute kidney injury[6]. Several parameters (vital signs and urinary output [UOP] equal or greater than 0.5 mL/kg/h, central venous pressure [CVP], mixed venous oxygen saturation [SvO_2], arterial lactate concentration, base deficit and pH, and so on) may be considered as resuscitation end points.[7,1,8] In low- and middle-income countries (LMICs) with limited resources, it is almost impossible to assess hemodynamic status using some of these parameters, such as CVP and SvO_2, due to inconsistent availability of consumable and durable equipment needed for measurement and limited personnel to interpret the values and maintain the machinery. Instead, vital signs and UOP are used as resuscitation end points in such settings.

Ultrasonography is extensively used as a noninvasive, rapid, and low-cost assessment of volume status. Respiratory variation in inferior vena cava diameter (ΔIVC) is useful in assessing volume status.[4] The IVC diameter is not affected by the vasoconstrictor compensatory mechanisms induced by volume loss.[9-11] The IVC diameter is effective in distinguishing patients who may respond to fluid from those who may not respond. The use of IVC diameter revealed that the IVC volume is greater in the patients without hypovolemia than in those with hypovolemia.[4] Studies on the correlation between IVC-CI and CVP revealed that the higher the IVC-CI, the lower the CVP, suggesting that IVC-CI is a useful minimally invasive and reliable parameter to assess volume status in critically ill patients.[7,12] Thus in settings with minimal access to invasive monitoring, IVC-CI measurements may prove a useful adjunct in addition to UOP monitoring.

Furthermore, in patients presenting with severe sepsis with acute anuric/oliguric kidney injury, monitoring UOP is not an adequate parameter for assessing volume status.[1,13] Monitoring UOP can delay patients from receiving the definitive surgical management, thus likely increasing morbidity and mortality for patients already in critical condition.

Most of the studies that used the IVC diameter and collapsibility index to assess hemodynamic response to fluid therapy were performed on patients on positive pressure ventilation.[5] Patients with septic shock who received mechanical ventilation with the IVC-CI of 15% or greater responded to volume expansion with IVF.[14] In contrast, in patients with spontaneous respiration in septic shock, an IVC-CI of 50% or greater indicates responsiveness to IVF with a positive predictive value of 75% and a negative predictive value of 80%.[5,15] An IVC-CI of 40%-50% has been reported as the cutoff point in this population, such that patients with an IVC-CI less than 40% do not demonstrate an increase in cardiac output with fluid resuscitation, but those with an IVC-CI greater than 50% do respond.[5,16]

In the present study, we sought to assess the utility of IVC-CI compared to UOP as a primary indicator of hemodynamic response in patients with hemodynamic instability presenting with suspected intra-abdominal infection. We chose to observe the time until hemodynamic resuscitation was confirmed by each modality. Decreased time to confirmed resuscitation will translate to shorter time until definitive surgical management and more efficient utilization of limited operating room time.

Materials and methods

This was a retrospective review of prospectively collected data of adult patients with intra-abdominal infection admitted at Kigali University Teaching Hospital from August 2015 to March 2016. Patients with known congestive heart failure were excluded from the study.

The study consisted of assessing volume status and fluid responsiveness in patients with intra-abdominal infections. Both the IVC-CI and the UOP were measured in patients meeting the inclusion criteria. In addition to this, clinical parameters (blood pressure, heart rate, and oxygen saturation) and paraclinical parameters (urea, creatinine, white cell count, hemoglobin, and platelets) were recorded.

After triage in the emergency department, patients with intra-abdominal infections who required resuscitation with IVFs prior to operative management were enrolled in the study. Baseline IVC collapsibility index was calculated using a portable Sonosite ultrasound machine. Fluid status was assessed using ultrasound and UOP measurement after the first hour, then after each subsequent 2 h until a decision was made to take the patient to the operating room.

To measure UOP, the urethral catheter was inserted, and urine was collected immediately after catheter insertion was emptied, and for patients who came to the Emergency Department with inserted urethral catheters, the collection bag was emptied before administration of IVFs. The UOP was calculated hourly and measured as mL/kg/h. To avoid the interobserver variability, the ultrasound measurements were performed by the primary investigator after receiving a 5-hour training from emergency medicine personnel with board certified ultrasound skills.

Data were collected prospectively on a preestablished questionnaire and were processed using EpiData. Statistical analysis was performed with SPSS, version 16 and Stata, version 13.

To measure differences between categorical variables, Fisher's exact test or chi-squared test was utilized, wherever appropriate. For continuous variables, Student's *t*-test or Wilcoxon rank sum test was used, wherever appropriate. An alpha level of 0.05 was used as the threshold for statistical significance.

The Institutional Review Board of the University of Rwanda and the ethics committee of Kigali University Teaching Hospital approved the study protocol. Patients' consent was obtained before enrollment in the study.