Journal of Critical Care xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Microcirculatory perfusion derangements during continuous hemofiltration with fixed dose of ultrafiltration in stabilized intensive care unit patients

G. Veenstra *, B. Scheenstra, M. Koopmans, W.P. Kingma, H. Buter, E.C. Boerma

Medical Centre Leeuwarden, ICU, Leeuwarden, the Netherlands

ARTICLE INFO

Keywords:
Microcirculatory blood flow
SDF
Negative fluid balance
Renal replacement therapy
Acute kidney failure

ABSTRACT

Introduction: Acute kidney injury (AKI) is a well-known complication in critically ill patients. Little is known about the timing and the ultrafiltration dose after initial resuscitation. In vivo microscopy of the microcirculation has been suggested as alternative for the assessment of volume status. Previous studies contribute to the understanding that intravascular hypovolemia is reflected by microcirculatory blood flow changes not detected by conventional methods. The aim of our study was to assess microcirculatory blood flow changes during negative fluid balance ultrafiltration in patients with oliguric AKI.

Materials and methods: Patients with oliguric AKI on renal replacement therapy were included after hemodynamic stabilization. Target was a predefined negative fluid balance; subsequently, a stepwise decrease in amount of substitution fluid was achieved. The data were recorded at baseline and after each change.

Results: Fifteen patients were included in the study. Microcirculatory blood flow index did not change significantly between baseline and endpoint (2.90 [2.87-3.00] vs 2.90 [2.75-3.00], $P = .57$). During treatment, heart rate decreased from 96 (80-111) to 94 (79-110) beats per minute ($P = .01$), without a significant change in mean arterial blood pressure (80 [68-95 mm Hg] vs 79 [65-91 mm Hg], $P = .5$).

Conclusion: Microcirculatory blood flow is not altered by reduced substitution during renal replacement therapy.

1. Introduction

Acute kidney injury (AKI) is a recognized complication in patients admitted to the intensive care unit (ICU); 6% of ICU patients will develop oliguric kidney failure. The mortality rate increases up to 60% in this group, with an increased risk for chronic kidney disease [1,2]. Oliguric AKI poses several challenges to the ICU physician. Although still subject to debate, there seems to be consensus to some extent about the initial timing, dose, and type of renal replacement therapy (RRT) in the acute phase of AKI. However, little is known about the timing and the ultrafiltration dose after the initial sepsis resuscitation [3–5].

This observation is noteworthy because optimal fluid management appears to be relevant. Although fluid therapy remains an important cornerstone in sepsis treatment, fluid overload is clearly an independent risk factor for morbidity and mortality. More importantly, an independent association exists between negative fluid balance and decreased 90-day mortality [6–11]. However, in the clinical setting, assessing the balance between the ongoing need for fluid therapy and fluid overload is difficult. Practical guidelines concerning when and how to reduce positive fluid balances seem to be lacking. In the last decade, in vivo microscopy of microcirculatory blood flow has been suggested to be an alternative modality for assessing volume status. In an animal model of hemorrhagic shock, the microcirculatory blood flow tracked progressive blood loss, whereas the heart rate and blood pressure changes occurred only in the late phase of shock [12]. In the human setting of fluid resuscitation, both passive leg raising and intravascular volume expansion were associated with increased microcirculatory blood flow during septic shock [13]. In the setting of chronic renal failure, rapid changes in volume status during hemodialysis with ultrafiltration were detected by significant changes in microcirculatory blood flow; however, these rapid volume status changes were not sensed by standard macrohemodynamic variables [14]. Pranskunas et al [15] not only linked improved microvascular blood flow to fluid therapy but also established its relationship with attenuated clinical signs of impaired organ perfusion. These studies contribute to the understanding that intravascular hypovolemia can reflect microcirculatory blood flow changes, which are not sensed by conventional methods, and that the technique can track rapid changes [16].

The aim of the present study was to assess potential changes in microcirculatory blood flow during the beginning of negative fluid balance ultrafiltration after the initial stabilization of shock patients with oliguric AKI. We hypothesized that mild negative fluid balance in this patient group is not associated with impaired microcirculatory blood flow.

* Corresponding author. ICU, Henri Dunantweg 2, Postbus 888 8901 BR Leeuwarden.
E-mail address: gerke52@gmail.com (G. Veenstra).

http://dx.doi.org/10.1016/j.jcrc.2014.02.008

2. Materials and methods

2.1. Patients

This single-center, prospective, observational study was approved by the medical ethics committee (Medical Centre Leeuwarden, the Netherlands) and registered with ClinicalTrials.gov number NTC 01362088.

The patients with oliguric kidney failure who were treated with RRT after hemodynamic stabilization were eligible for the study. *Hemodynamic stabilization* was defined as the absence of the need for fluid therapy or positive fluid balance, a mean arterial blood pressure greater than 60 mm Hg, a central/mixed venous oxygen saturation greater than 65%, normal lactate levels, and stable or decreased inotropic dosage.

The inclusion criteria were patients older than 18 years, informed consent, and a clinical status indicative of negative fluid balance. The exclusion criteria included the inability to obtain sidestream dark field (SDF) images, such as maxillofacial surgery.

2.2. Protocol

Before the start of the protocol, the attending physician determined the need for and the amount of negative fluid balance for the next 12 hours. Subsequently, a stepwise decrease in the amount of substitution was achieved (Fig. 1). Each step lasted 1 hour. Sidestream dark field imaging of the sublingual area was obtained after each substitution step. At the end of the protocol, the patient was placed in the Trendelenburg position for several minutes, and simultaneous SDF imaging was performed.

2.3. Renal replacement therapy

All of the patients were treated using continuous venovenous hemofiltration (CVVH) (multiFiltrate, Fresenius Medical Care, Bad Homburg, Germany), equipped with a Nipro UF-205 dialyzer (Nipro Corporation, Osaka, Japan). During treatment, the blood flow was standardized at 200 mL/min using an ultrafiltration flow at 3000 mL/h. The total amount of postfilter buffered substitution solution (SH 44 HEP or SH 53, Dirinco, Rosmalen, the Netherlands) was adjusted according to the preset net fluid balance. The regional anticoagulation was achieved using trisodium citrate.

2.4. Microvascular imaging and analysis

Sidestream dark field imaging, which is a stroboscopic light-emitting diode, ring-based imaging modality, is incorporated in a handheld device. Sidestream dark field imaging has been validated for clinically observing the microcirculation. If a wavelength within the hemoglobin absorption spectrum (eg, 530 nm) is chosen, red blood cells will appear dark. Sidestream dark field images are obtained from 3 different regions of the sublingual microcirculation [17,18].

Clips were acquired and stored using a digital videotape (Video Walkman GV-D 1000E, Sony, Tokyo, Japan). Subsequently, the images were captured in 5- to 10-second representative AVI-format video clips (SonyDVgate, Sony).

The images were randomly presented to prevent interimage coupling. Offline analysis was performed using the AVA 3.0 software package (MicroVision Medical, Amsterdam, the Netherlands) in compliance with the recommendations of a roundtable conference [19].

2.5. Data

The following data were recorded at baseline: general characteristics and severity of illness according to Acute Physiology and Chronic Health Evaluation (APACHE) IV and Sequential Organ Failure Assessment scores calculated over the first 24 hours after ICU admission. Macrohemodynamic variables, SDF images, central venous oxygen saturation, and arterial blood gases were recorded at baseline and after each substitution step.

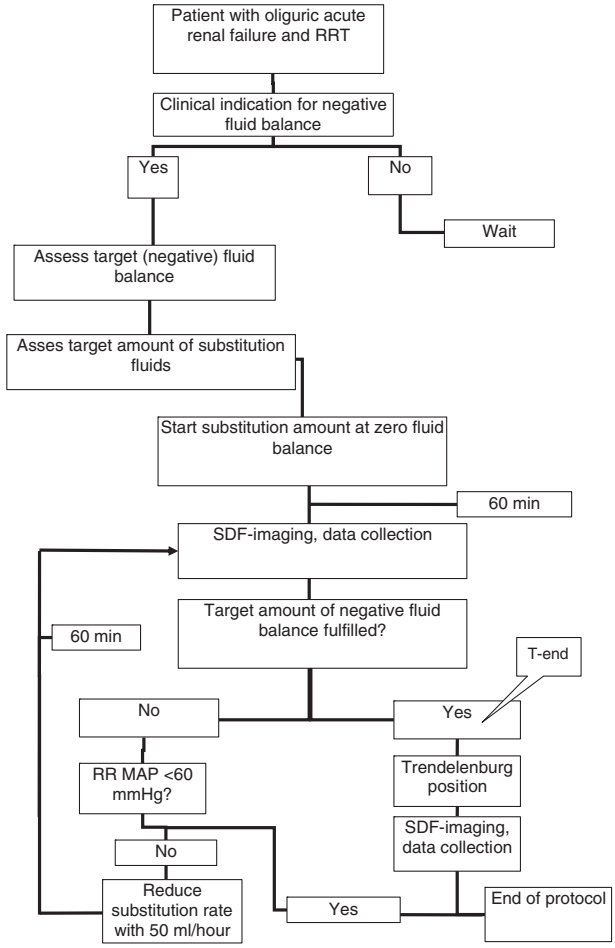

Fig. 1. Protocol.

Table 1
Baseline characteristics

	N = 14
Age, y	76 (69-79)
Sex, male/female, n	11/3
Reason for ICU admittance, n (%)	
Sepsis	8 (57%)
Cardiogenic shock after cardiac surgery	4 (29%)
Other	2 (14%)
APACHE II	26 (20-29)
APACHE IV	93 (46-107)
SOFA	12 (10-13)
Hospital mortality (%)	25%
Mechanical ventilation, n (%)	14 (100%)
Number of patients on vasopressors, n (%)	6 (43%)
Number of patients on inotropics, n (%)	1 (7%)
Creatinine before admittance, mmol/L	86 (76-135)
Diuresis at start protocol, hourly, mL	0.0 (0.0-11.25)
Creatinine at start protocol, mmol/L	125 (71-173)
Urea at start protocol, mmol/L	9.1 (8.0-13.8)
Length of stay ICU, d	15 (10-28)
Length of stay hospital, d	26 (14-32)
ICU-treatment before inclusion, d	5 (3-7)
RRT, d	7 (6-12)
Developed chronic kidney failure, n (%)	2 (14%)

SOFA: Sequential Organ Failure Assessment.

Please cite this article as: Veenstra G, et al, Microcirculatory perfusion derangements during continuous hemofiltration with fixed dose of ultrafiltration in stabilized intensiv..., J Crit Care (2014), http://dx.doi.org/10.1016/j.jcrc.2014.02.008