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Original article

# Influence of different dialysis modalities in the measurement of resting energy expenditure in patients with acute kidney injury in ICU

Cassiana R. de Góes*, Barbara Perez Vogt, Ana Claudia S. Sanches, André L. Balbi, Daniela Ponce

*Faculdade de Medicina de Botucatu, UNESP Univ Estadual Paulista, Department of Internal Medicine, Botucatu, São Paulo, Brazil*

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SUMMARY

*Background:* Currently, the execution of indirect calorimetry, which is considered the gold standard for measuring energy expenditure, is not indicate during dialysis, and it may interfere on nutritional therapy of these patients. This study aimed to evaluate the resting energy expenditure (REE) in patients with severe acute kidney injury treated by different modalities of dialysis and to identify whether dialysis influences on REE.

*Methods:* This was a prospective cohort study that evaluated patients admitted in intensive care units with diagnosis of acute kidney injury AKIN-3, mechanically ventilated, and submitted to conventional hemodialysis (CHD), extended hemodialysis (EHD) or high volume peritoneal dialysis (HVPD). Indirect calorimetry was performed at pre dialysis time and during the dialysis procedure. Parameters that could change REE were also evaluated.

*Results:* One-hundred patients undergoing 290 dialysis sessions were evaluated, with mean age 60.3 ± 17 years, 69% were male and 74% have died. There was no significant difference between REE of predialysis time and during dialysis time (2156 ± 659 kcal vs. 2100 ± 634 kcal, respectively, $p = 0.15$). No difference was observed in the REE before and during dialysis of different modalities. There were no differences between parameters pre and during dialysis of each modality. There was only a difference in norepinephrine dose, which was higher in pre dialysis time in HVPD and EHD modalities, compared with CHD modality. Moreover, during dialysis time, EHD modality had significantly higher VAD compared to other dialysis modalities.

*Conclusion:* The three evaluated modalities did not change REE. Indirect calorimetry can be performed during dialysis procedures and there was no difference between ventilation parameters, sedatives use, body temperature and VAD in both moments.



## 1. Introduction

Acute kidney injury (AKI) is a common complication in hospitalized patients and affects approximately 35% of patients in intensive care unit (ICU) [1]. Severe AKI requiring dialysis is a condition associated with high morbidity and mortality [2]. Observational studies have reported an association between malnutrition, caloric deficit, and worse renal outcome and patients survival in ICU [3,4]. The condition of these patients is complex because of changes in use of substrates, insulin resistance, hyperglycaemia, and hypercatabolism in response to neuroendocrine alterations and inflammatory mediators. Such complex physiological disorders turn the nutritional therapy more difficult [5,6].

Adjusting nutritional support of these patients is important to prevent complications associated with over and underfeeding, which increase morbidity and mortality rates. The accurate determination of caloric requirement is necessary since it is specific to each person, varying according to age, weight, height, race and it is also affected by primary disease, treatments and evolution [7]. Energy supply goal estimated by indirect calorimetry (IC) is recommended by guidelines and it has associated with better outcomes in critically ill patients [3,8].

Although considered the gold standard for energy expenditure (EE) measurement in critically ill patients, IC has limitations in

* Corresponding author. Paranapanema Avenue, 165, Avaré, São Paulo 18701-240, Brazil. Fax: +55 1438116005.
*E-mail address:* cassiana.goes@yahoo.com.br (C.R. Góes).

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clinical practice in ICU. High cost and the need for specialized staff can be limiting factors in several centers. Moreover, many patients are ineligible for this measurement according to the recommendations. The reasons for ineligibility may be high fractions of inspired oxygen ($FIO_2$), air leakage on the system or originated from chest tubes; patient hemodynamic instability; recent changes or disconnect in ventilator and extracorporeal circulation, such as oxygenation or hemodialysis [9–11].

When AKI is severe, dialysis is often required as long as treatments for specific conditions are applied. AKI requiring renal replacement therapy (RRT) prevalence has increased in recent years [12,13]. Two modalities of dialysis are usually provided: continuous or intermittent. Both methods achieve a satisfactory degree of metabolic control, but require hours of therapy. There are also recommendations to not perform IC during dialysis may preclude EE measurement and hinder nutritional therapy in these patients.

Patients' ineligibility to IC is supported by older studies which showed the increase of oxygen uptake (VO2) and removal of $CO_2$ during hemodialysis. Both may alter the EE measurement [14,15], but this contraindication needs to be further investigated, due to measuring EE importance in AKI patients.

Thus, the present study aims to evaluate the resting energy expenditure (REE) measured by IC of severe AKI patients undergoing different dialysis modalities, and identify if dialysis influences REE.

## 2. Subjects and methods

Prospective cohort study that evaluated patients older than 18 years admitted, from March 2013 to December 2015, in ICU with diagnosis of AKI stage 3 according to the criteria of KDIGO 2012 [16], with clinical diagnosis of acute tubular necrosis (ATN), and necessity for renal replacement therapy were included. Patients were mechanically ventilated and IC was performed daily, prior to dialysis (non-dialysis time), and during dialysis procedure.

Patients with AKI caused by other etiologies stages 4 and 5 chronic kidney disease (Glomerular Filtration Rate - TFG - <30 ml/min estimated by the Modification of Diet in Renal Disease – MDRD) [17] were excluded. To estimate TFG, patient's baseline serum creatinine, defined as the most recent serum creatinine value obtained before admission, not preceding 12 months of the hospitalization date was considered. If this value was unknown or from 12 months before admission, the lowest value of baseline serum creatinine observed during follow-up was considered [18]. Kidney transplant patients were also excluded.

Patients with factors that could lead to inaccuracy in the REE measurement by IC were also excluded. These factors can be: fraction of inspired oxygen ($FiO_2$) greater than 60%; positive end-expiratory pressure (PEEP)> 10 cm $H_2O$; presence of agitation; use of neuromuscular blockers and any leakage of air (into the ventilator circuit, around the endotracheal tube cuff, or inpatient from a drain or bronchopleural fistula).

The protocol was initiated at the time of dialysis indication, and terminated at the time of the dialysis suspension due to recovery of renal function or death.

This study was approved by the institution ethics committee. The consent form was signed by the participant's legal guardian prior to entry into the study.

### 2.1. Energy expenditure measure

REE is usually measured due to the impossibility of achieving the conditions for measuring the basal EE in critical patients. To ensure REE measurement, the patients were in supine position resting for at least 30 min prior to the measurement. The environment was thermoneutral for the 30 min prior to the measurement and during it. They have not used additional painkillers and sedatives within 30 min of IC initiation; no procedures within 60 min before the IC beginning (only the dialysis procedure, during dialysis time); no general anesthesia within 8 h of IC onset; and continued parenteral and/or enteral nutrition during the data collection period.

IC was performed using calorimeter Quark RMR unit (Cosmed, Rome, Italy), which was calibrated before each measurement. The exam lasted 30 min on average. It was desired that patients reached steady state during the test. The steady state was defined as a variation <10% in the oxygen consumption measurements (VO2) and carbon dioxide production (VCO2), and <5% in respiratory quotient in every minute.

In addition to REE measured in two moments, parameters that can influence REE were also evaluated, as ventilatory parameters (minute volume, total current volume, PEEP, FIO2), continue sedation and vasoactive drugs during all measurements.

### 2.2. Dialysis

The dialysis method was chosen by nephrologists, according to patient's clinical condition, namely:

- High volume peritoneal dialysis (HVPD): Sessions conducted through flexible catheter implanted in peritoneal cavity ("Tenckhoff" catheter), performed at bedside and with no direct visualization by the nephrology team. The dialysis solution used was Dianeal Baxter (Na = 135 mEq/L, Ca = 3.5 mEq/G, K = 0 mEq/L, Mg = 1.5 mEq/L, lactate = 40 mEq/L, Glucose = 1.5, 2. 5 or 4.25%), with exchanges done by HomeChoice cycler (Baxter). Continuous sessions were performed, each session lasting 1 day (24 h).
- Conventional Hemodialysis (CHD): Sessions were conducted through double lumen catheter in central venous access (jugular, subclavian or femoral), using machine Fresenius 4008S or Gambro K200S and capillary cellulose acetate or polysulfone. Each session lasted 4 h, using blood flow 200–300 ml/min and dialysate flow 300–500 ml/min. The dialysis bath concentrations were adjusted according to patient individual necessity.
- Extended Hemodialysis (EHD): Sessions conducted through double lumen catheter inserted into a central venous access (jugular, subclavian or femoral), using machine Fresenius 4008S or Gambro K200S and capillary cellulose acetate or polysulfone. Each session lasted 6 or 10 h, blood flow 200–300 ml/min and dialysate flow 300–500 ml/min. Dialysis bath concentrations were adjusted according to patient individual necessity.

### 2.3. Statistical analysis

Results are presented as median and first and third quartiles, mean ± standard deviation or percentage, according to variables distribution.

For comparisons of clinical characteristics of patients among different dialysis modalities, ANOVA with post hoc Tukey, or Kruskal–Wallis test with post hoc Dunn was used. The analysis of the moments before and during dialysis in each dialysis modality was performed using the mixed model for repeated measures followed by Tukey for variables with symmetrical distribution or generalized linear model with gamma distribution for variables with asymmetric distribution. Categorical variables were analyzed by trend test to check changes between the moments. It was adopted as statistically significant $p < 0.05$.

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