ORIGINAL RESEARCH

Body Composition Affects Urea Distribution Volume Estimated by Watson's Formula

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Objective: Dialysis machines use the Watson formula (Vwatson) to estimate the urea distribution volume (UDV) to calculate the online Kt/V for each dialysis session. However, the equation could give rise to inaccuracies. The present study analyzes whether body composition affects UDV estimated by Vwatson in comparison to bioimpedance spectroscopy (Vbis) as the reference method.

Design: This is a transversal study performed in the setting of a hemodialysis unit.

Subjects: Prevalent hemodialysis patients.

Intervention: The same day, UDV was measured using Vwatson and Vbis. We compared their results.

Main Outcome Measure: Differences between UDV using Watson equation and Vbis.

Results: We included 144 prevalent patients. Vwatson overestimated the volume with regard to Vbis (Vwatson − Vbis) by 2.5 L (1.8 L; $P = .001$). We found an excellent correlation between the 2 methods. A higher mean Vwatson − Vbis value was correlated to older age ($P = .03$), body mass index ($P = .01$), fat tissue index ($P = .001$), lower lean tissue index ($P = .001$), lower extracellular water ($P = .01$), and intracellular water ($P = .001$).

Conclusion: Body composition affects UDV estimated by Vwatson, thus modifying the result of Kt/V. In young patients who present more lean tissue and less fat tissue, Kt/V is underestimated with Vwatson.

Introduction

THE DIALYSIS DOSE is usually set based on urea clearance, which is calculated using the Kt/V formula. In this equation, "K" represents urea clearance during the dialysis session, "t" is the time of dialysis, and "V" is the urea distribution volume (UDV).[1] This volume is equivalent to total body water (TBW). UDV is commonly estimated using the Watson formula (Vwatson), which is based on anthropometric measures that influence body composition, such as sex, age, weight, and height.[2] UDV as measured by Vwatson has been shown to be more closely correlated to the modeled UDV than when using other equations.[3,4] Accordingly, dialysis monitors use Vwatson to estimate the distribution volume to calculate the online Kt/V for each dialysis session. However, Vwatson could give rise to inaccuracies.[5]

Bioimpedance spectroscopy is a simple and noninvasive technique based on the resistance of tissue to the flow of an alternating current ranging from 5 to 1000 kHz in frequency.[6-9] It has been validated against gold standard methods for assessing body composition and hydration state and is therefore considered a reference method.[7]

The present study analyzes whether body composition affects the UDV estimated by Vwatson in comparison to Vbis as the reference method.

Methods

Study Population

Prevalent hemodialysis patients aged more than 18 years and of Caucasian race were included in this cross-sectional, noninterventional study. Exclusion criteria were amputations and carriers of pacemakers, implantable defibrillators, or metallic prostheses because of contraindications or difficulties in interpreting the bioimpedance results. We also excluded patients with clinical instability, defined as any hospital admission within 3 months before the start of the study, and patients with recent changes in dry weight or body composition.

Baseline characteristics were recorded, including age, sex, etiology of clinical kidney disease, percentage of diabetes, dialysis vintage, and mean Daugirdas Kt/V.

Characteristics of Renal Replacement Therapy

Patients were receiving 3 sessions of 4 hours of hemodialysis per week. Seventy patients were treated by

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The authors declare that they have participated in the present study. C.R. did data collection from patients and estimated volume of urea distribution using the Watson equation. S.A. contributed to the design of the study and performed bioimpedance spectroscopy studies. K.V. and J.A. performed bioimpedance spectroscopy studies. B.Q. contributed to statistical analysis and the design of the study. J.M.L.G. designed the study. A.V. performed bioimpedance spectroscopy studies, contributed to the design of the study, and wrote the article.

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postdilution online hemodiafiltration, and 74 patients were treated by hemodialysis. We used the monitor Artis AK 200 ULTRA S (Gambro, Stockholm, Sweden) and the dialyzers 4008 and 5008 (Fresenius Medical Care [FMC], Bad Homburg, Germany). Dialyzers were FX1000 (FMC; Helixone membrane; ultrafiltration coefficient of 75 mL/h × mm Hg; effective surface of 2.2 m^2; wall thickness of 35 μm; and lumen of 210 μm) and Polyflux 210H, (Gambro; polyamide membrane; ultrafiltration coefficient of 85 mL/h × mm Hg; effective surface area of 2.1 m^2; wall thickness of 50 μm; and lumen of 215 μm) for online hemodiafiltration and FX60 (FMC; Helixone membrane; ultrafiltration coefficient of 46 mL/h × mm Hg; effective surface of 1.4 m^2; wall thickness of 35 μm; and lumen of 185 μm) for hemodialysis. Mean blow flow rate was 403 ± 97 mL/min and mean dialysate flow was 604 ± 127 mL/min.

Measurement of Body Composition

UDV Estimation Using Bioimpedance Spectroscopy

Body composition was analyzed by Vbis, BCM (FMC, Bad Homburg, Germany). Measurements were taken in the limbs contralateral to the arteriovenous fistulae after a 10-minute resting period in the supine position before the dialysis session according to operating instructions advice. We collected body composition and hydration parameters. The recorded hydration parameters were TBW (L), which is equivalent to UDV, extracellular water (ECW [L]), intracellular water (ICW, [L]), and overhydration (OH, [L]), defined as water not included in the extracellular and extracellular compartments and considered as an excess of water. Body composition parameters in turn were fat tissue index (FTI) and lean tissue index (LTI), defined respectively as fat and lean tissues adjusted for body surface (kg/m^2).

UDV Estimation Using Vwatson

We used the following formulas to estimate UDV:

$$\text{Vwatson for males} = 2.447 - (0.09156 \times \text{age}) + (0.1074 \times \text{height}) + (0.3362 \times \text{weight})$$

$$\text{Vwatson for females} = -2.097 + (0.1069 \times \text{height}) + (0.2466 \times \text{weight})$$

The weight corresponded to dry weight.

We analyzed Vwatson and Vbis in the same dialysis session for each patient. To avoid changes in hemodialysis, we estimated them when the sessions had been finished. To calculate the online Kt/V, we collected data from "K" using online ionic dialysance given by monitors, time of the session (t) in minutes, and "V" using Vwatson and Vbis. Two different Kt/V values were therefore estimated.

Statistical Analysis

The SPSS version 17.0 statistical package (Chicago, IL) was used for data processing and analysis. The Kolmogorov-Smirnov test was performed to determine whether the values followed a normal distribution. Quantitative variables were expressed as means and standard deviations or medians (interquartile ranges). Qualitative variables were expressed as percentages. We calculated the numerical difference in UDV between Vbis (as reference) and Vwatson. To assess the factors associated with the overestimation or underestimation of UDV with both methods, we compared the mean of the differences with each collected value using a univariate Student *t* test for independent samples or analysis of variance as appropriate. Multivariate analysis was performed when differences in variable were significant in the univariate analysis. Correlations and agreement were also established between the differences in the estimation (Vwatson − Vbis) and the variables using the Spearman rho test, Bland-Altman test, and intraclass correlation coefficient. Statistical significance was considered for $P < .05$.

Results

The study population consisted of 144 patients. The baseline characteristics, including the measurement of body composition using Vbis, are listed in Table 1. The mean UDV was 34.1 ± 6.5 L and 31.6 ± 7.0 L using Vwatson and Vbis, respectively (difference 2.5 ± 1.8 L, $P = .001$). It can be concluded from Table 2 that this difference remains on dividing patients into body mass index (BMI) tertiles. An excellent correlation was observed between Vwatson and Vbis as depicted in Figure 1 (Spearman rho = 0.846; P = .001) and by Bland-Altman test in Figure 2. Intraclass correlation coefficient between them also showed an excellent agreement 0.87 (0.80-0.93). Mean online Kt/V was 1.62 ± 0.36 and 1.78 ± 0.46 using Vwatson and Vbis, respectively, and the difference between them was statistically significant ($P = .001$).

For assessing the factors associated to increased differences in UDV between both methods, we performed univariate Student *t* test and multivariate logistic regression, which showed old age, higher BMI and FTI, and lower LTI, ICW, and ECW to be related to greater differences between Vwatson and Vbis (Table 3). We did not find significant association between Vwatson and Vbis differences and sex and diabetes.

Correlations between mean Vwatson − Vbis and patient age, ICW, ECW, BMI, FTI, and LTI are depicted