

# Correlation Between Predialysis Systolic Blood Pressure and Predialysis Hydration Status in Hemodialysis Patients

## Correlación entre la Presión Arterial Sistólica Prediálisis y el estado de Hidratación Prediálisis en Pacientes de Hemodiálisis

Magdalena Castro<sup>\*,\*\*</sup>; Rodrigo Orozco<sup>\*</sup>; Pedro Figueroa<sup>\*\*\*</sup>; Cristina Hertz<sup>\*\*\*</sup> & Victoria Aspíllaga<sup>\*\*\*</sup>

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**SUMMARY:** One of the goals of hemodialysis is to maintain normal hydration status in ESRD patients. Pre hemodialysis systolic blood pressure is usually used as a clinical parameter of hydration status and to set ultrafiltration rate before Hd. It is unclear how much pre-Hd SBP correlated with hydration status. The aim was to determine correlation between pre-Hd SBP and hydration status before Hd. An observational correlation study was performed in two dialysis centers in Santiago, Chile, from January-June, 2011. Adult patients in Hd for at least three months, who gave their informed consent were included. Patients with pacemaker, amputee, hospitalized and metallic prostheses were excluded. Total-body water and overhydrated were assessed with bioimpedance spectroscopy before the first and third dialysis session of the week. Pre-Hd SBP, pre-Hd body weight, pre-Hd TBW and pre-Hd OH, were analyzed using Pearson correlation and linear regression model. 96 measurements were assessed, 52 % were male with median age 59.5 years. The correlation between pre-Hd SBP and pre-Hd overhydration was  $r=0.33$ , and total body water  $r=0.15$ , with a predicted value,  $R^2=0.10$  and  $R^2=0.14$  respectively. Pre-Hd SBP had low correlation with pre-Hd hydration status and by itself, is not a reliable parameter to set ultrafiltration rate before Hd. Nevertheless Pre-Hd body weight predicted in 70 % the pre-Hd TBW.

**KEY WORDS:** Hemodialysis; Systolic blood pressure; Bioimpedance spectroscopy; Fluid status; Ultrafiltration rate.

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### INTRODUCTION

In Chile, the final stage renal disease (ESRD) is a public health problem due to its high morbidity and mortality rates, poor prognosis and high treatment costs. Chile spends over US\$ 120 million per year on dialysis alone. In 2010, 15462 patients with ESRD received chronic hemodialysis (HD); this represents a prevalence rate of 90 per 100,000 inhabitants. That same year 1689 patients with ESRD receiving chronic HD died, indicating a mortality rate of 11.2 % (Poblete, 2010) and in

2012 was 10.8 %. The main causes were cardiac (34.8 %), infections (18 %) y cerebrovascular (9.2 %) (Poblete).

The primary cause of mortality in patients on HD is a cardiac complication, accounting for one-third of such deaths. The principal cardiovascular risk factor is arterial hypertension, which has a prevalence rate of 44.4 % in ESRD patients. (Poblete) Maintaining blood volume in normal ranges helps to prevent

\* Dialysis registered nurse (RN) and Master in Epidemiology, Dialysis Unit Clínica Las Condes, Santiago Chile

\*\* Research Unit, Clínica Las Condes, Santiago, Chile.

\*\*\*Condell Dialysis Center, Fresenius Medical Care Chile, Santiago, Chile.

the development of arterial hypertension and cardiovascular complications. In order to accomplish these, it is necessary to have an adequate blood volume monitoring and manage the hydration status of HD patients (Biesen *et al.*, 2011). However, it is difficult to determine a patient's hydration status by clinical signs and symptoms, such as: the presence of edema in the upper and lower extremities, jugular venous distension, difficulty breathing, systolic blood pressure (SBP), increase of body weight pre-dialysis, signs and symptoms of pulmonary edema and tolerance to ultrafiltration during therapy. An objective assessment of hydration status would allow for the adaptation of dialysis therapy to the patient's specific needs and improve accuracy in the determination of pre-HD extraction volumes (ultrafiltration), which would result in better blood volume control as well as contribute to the prevent and control the development of arterial hypertension and cardiovascular complication in these patients. Establishing the hydration status of HD patients is necessary in order to maintain blood volume within normal ranges.

A series of invasive techniques have been described for determining hydration state and blood volume, such as the method of bromide dilution, measurements of total body potassium, deuterium dilution to estimate total-body water (TBW) (Mesa, 2009). The invasive nature of these techniques has restricted research. There exist noninvasive techniques for estimating hydration status, such as dual x-ray energy absorption and measuring the diameter of the inferior vena cava by ultrasound (Agarwald *et al.*, 2011). However, the clinical application of these methods has been limited, due to their high cost and the difficulty to use before hemodialysis. Recently the application of bioimpedance spectroscopy (BIS) has been proposed to measure the hydration status of patients with ESRD. This technique is noninvasive, low cost, safe, fast, easy to implement and reproducible (Chamey *et al.*, 2002; Wabel *et al.*, 2009). Several studies have provided validation for the use of BIS in obtaining an objective measures of TBW as well as the overhydrated status in HD patients (Wabel *et al.*, 2007; Passauer *et al.*, 2010) Chamney *et al.*, determined that there was no significant difference in body weight as estimated by clinical

evaluation versus BIS ( $R^2=0.839$ ,  $P<0.01$ ). Wabel *et al.*, (2007) evaluated the accuracy of hydration parameters as measured by BIS in 1.000 healthy individuals and patients receiving HD, as compared to the reference methods available. There was a high concordance for both groups between the TBW volume as estimated by BIS and the reference methods ( $R^2=0.88 \pm 0.17$ ). Therefore, it is feasible to use BIS to determine a HD patient's hydration status.

In the clinical practice pre-HD SBP is frequently use as an indicator of hydrations status, but we also observed that the pre-HD systolic blood pressure is not always an accurate indicator of pre dialysis hydration status and it is usually used among other clinical parameters to set ultrafiltration rate before hemodialysis.

With the purpose of having more clarity on this issue, the aim of this study was to determine the correlation and predictive ability of pre-HD SBP of the hydration status in HD patients. Our hypothesis was that pre-HD SBP is not an accurate indicator of the hydration status of HD patients and has a low predictive ability.

## MATERIAL AND METHOD

An observational correlational study was carried out from January to May, 2011 in the hemodialysis unit Clínica Las Condes and Nephrocare Fresenius, Santiago, Chile. The study was approved by the Research Ethical Committee of Clínica Las Condes. Patient recruitment was non-probabilistic, consecutive who met the inclusion criteria (Fig. 1). Adult patients ( $\geq 18$  years) with ESRD in HD therapy for at least three months who agreed to participate and signed an informed consent were included in the study. The following patients were excluded: those with pacemakers, because BIS produces electrical interference that could affect the functioning of their pacemakers and could have an effect on their measurements; hospitalized; those with a previous limb amputation, as they have decreased body tissue; and those with metallic prostheses, because metal devices electronically interferes with BIS measurements.

The variables studied were: pre dialysis systolic blood pressure, pre dialysis weight, pre dialysis hydration status consists in over hydration and total body water.

Systolic blood pressure was the mean of 3 measurements taken after 5 minutes rest in the supine position.

Pre dialysis weight (kg) was the weight of the patient before entering therapy. Patients were weighed with light clothing and no shoes.

Overhydration and total body water (L) were measured by BIS before entering hemodialysis and as recommended by the manufacturer.

Overhydrated is the excess body water higher than 2.5 L. The normal range for HD patients is between -1.0- 2.5 L.

Total body water is the sum of intracellular and extracellular water Height was measured, because it was a data request for BIS.

All patients were scheduled 20 minutes prior to their HD sessions. The device was used in accordance with the manufacturer's instructions. Chamey *et al.* (2007). Measurements were performed by a nutritionist with three years experience in the use of BIS and working with patients in HD and was also blind to the aim of the study.

All equipment used in this study (scale, BIS and Dinamap) were calibrated at the before its use. In order to avoid inter-observer variability, a single observer performed all measurements. The intra-observer variability on the BIS was controlled by the quality of the

measurement, which is reported by the device and it should range from 90-100 %. No measurements with quality less than 90 % were allowed.

**Statistical Analysis.** Data analysis was performed using Stata 12 statistical software (Stata Corp, College Station, Texas, USA). No sample size calculation was performed, as the primary aim was to determine correlation and predictive ability between independent variables (overhydration, body weight and TBW) and the outcome variable (SBP). We did not compare differences between groups. Descriptive statistics of normally distributed continuous data include the mean and standard deviation; non-normal continuous data was described using median and range. To determine if a stratified analysis by gender and age was needed, statistic tests to compare differences were used, the Student's t-test and Mann-Whitney test for normal / not normal distribution variables respectively. Pearson correlation coefficient (r) was calculated for all combinations of the following pre-HD variables: SBP, overhydration, weight and TBW. Linear regression was performed for each of the correlations and the predictive power of the independent variables (overhydration, body weight and TBW) on the outcome variable (SBP), was determined. P<0.05 was considered statistically significant.

## RESULTS

Ninety-six measurements were taken from 48 patients, 52.1 % of which were from male patients. The descriptive results of the studied variables are summarized in Table I. There was no need to perform stratified analysis, by sex and age.

Table I Descriptive statistics of measured predialysis variables

Variables	Female 23(48%) 46	Male 25(52%) 50	Total 48(100%) 96	P value
Age (yrs.) median (range)	56 (22-77)	60 (24-77)	59.5 (22-77)	0.49
Pre-HD SBP, media (SD)	143.7 (± 33.5)	153.6 (± 27.6)	148.9 (± 30.8)	0.11
Pre-HD overhydrated, media (SD)	1.4 (± 1.1)	1.59 (± 1.4)	1.5 (± 1.29)	0.65
Pre-HD TBW median (range)	26.6 (21.6-39.6)	35 (23.3-53.6)	29.3 (21.6-53.6)	0.001*
Pre-HD body weight median (range)	58.7 (46.3-93.4)	77.7 (55.7-132.5)	68.7 (46.3-132.5)	0.002*

\*p value <0.05

HD- hemodialysis; SBP- systolic blood pressure; TBW- total-body water

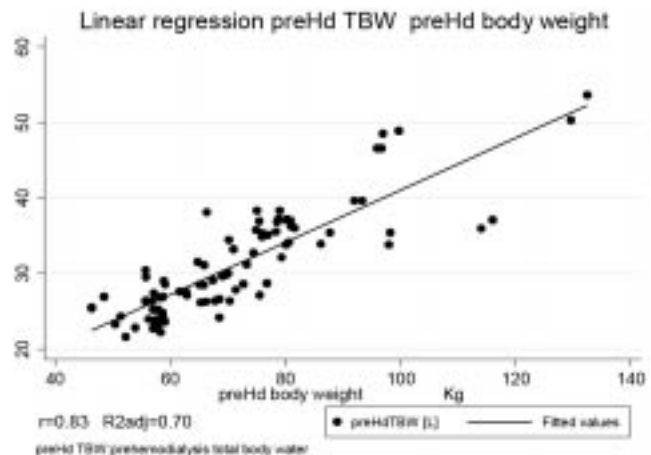
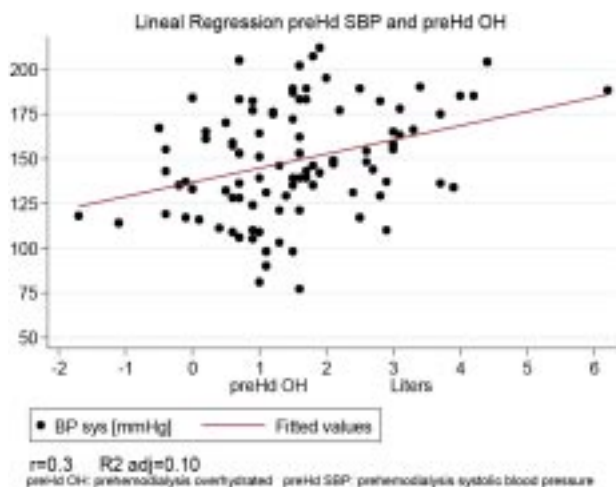
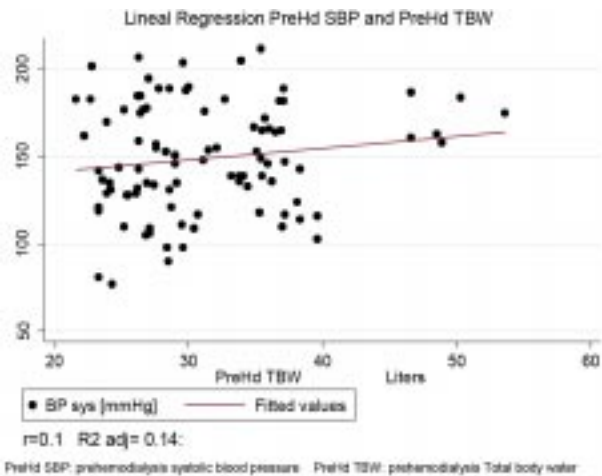
Table II Correlation between measured variables

n=96	Pre HD SBP	Pre-HD OH	Pre-HD TBW	Pre-HD body weight
Pre-HD SBP	1.0000	-		
Pre-HD OH	0.3609 0.0000*	1.0000	-	-
Pre-HD TBW	0.1599 0.1400	0.0274 0.7998	1.0000	-
Pre-HD body weight	0.2309 0.0305*	0.0632 0.5585	0.8457 0.0000*	1.0000

\*p value <0.05

HD- hemodialysis; SBP- systolic blood pressure; TBW- total-body water

Table II shows the correlation between pre-HD SBP and overhydration, TBW and body weight. The correlation between pre-HD SBP and overhydration was  $r=0.33$  ( $p=0.000$ ) and linear regression showed that overhydration was able to predict pre-HD SBP 10 % of the time (Fig. 1). The correlation between pre-HD SBP and TBW was  $r=0.15$  ( $p=0.140$ ) and linear regression was not significant ( $p=0.136$ ) (Fig. 2). The correlation between pre-HD body weight with pre-HD TBW was  $r=0.84$ , and was able to predict the 72 % of the TBW (Fig. 3). All other correlations and predictive models were not statistically significant. The distribution of the patients by hydration status and pre-HD SBP are shown in Table III.



## DISCUSSION

The findings of this study suggest that the predictive ability of pre-HD SBP on overhydration is low (12 %), showing that this is not a precise predictor of pre-HD hydration status in HD patients. Susantitaphong *et al.* (2013), studied the reliability of blood pressure parameters for dry weight estimation in hemodialysis patients. This study was conducted to explore the correlation between hydration status measured by bioimpedance and blood pressure parameters in chronic HEMO patients. Multifrequency bioimpedance analysis was used to determine pre- and post-dialysis hydration status in 32 stable HD patients. One of their results was that systolic blood pressure, mean arterial pressure, and pulse pressure significantly reduced after dialysis in the normohydration group but did not significantly change in the overhydration group. There have been previous studies on measuring hydration status with BIS and its benefit in guiding HD (Caravaca *et al.*, 2011) and still other have studied the impact of hydration status on cardiac health. Juan-García *et al.* (2012) and Cuba de la Cruz *et al.* (2009), showed that HD patients who have a weight gain of 2 kg was significantly related to the presence of hypertension. De Francisco *et al.* (2002), showed that increased extra-cellular liquid is frequent in patients with ESRD, especially those that are hypertensive, but there was no consensus on the role of the ECW in the cause of hypertension. We found no other study about the correlation between pre-HD SBP and pre-HD hydration status, and our results confirm that pre-HD SBP is not a reliable indicator of a HD patient's hydration status prior to initiating therapy. Another interesting result was the distribution by pre-HD SBP and pre-HD overhydrated state, where only 37 % showed hypertension and overhydrated and 63 % had another conditions, however not both. Pre-HD systolic blood pressure may or may not be associated with overhydration or dehydration in HD patients, therefore systolic hypertension ( $\geq 140$  mmHg) does not imply an overhydrated state and on the other hand hypotension (PAM  $< 60$  mmHg) is not necessarily a state of dehydration.

The limitations of our study include the fact that variables were only measured pre-HD. It would have been desirable to compare similarities

and differences in variables post-HD as well, however this was not possible, as patients were unwilling to remain for extra time needed to perform such measures, which would have taken another 30 minutes post-HD. Another limitation of the study was the small sample; further research is needed, so we can statistically confirm the results of this study and to perform a more thorough and accurate analysis of the relation between Pre-HD body weight and the pre-HD TBW.

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**RESUMEN:** Uno de los objetivos de la hemodiálisis es mantener la hidratación normal en pacientes ESRD. La presión arterial sistólica pre hemodiálisis, es usualmente utilizada como parámetro clínico del estado de hidratación y para fijar la velocidad de ultrafiltración antes de la hemodialisis. No está claro cuanto se correlacionan la presión arterial sistólica pre hemodialisis con el estado de hidratación. El objetivo fue determinar la correlación entre la PAS pre-hemodiálisis y el estado de hidratación antes de Hd. Se realizó un estudio de correlación observacional en dos centros de diálisis de Santiago de Chile, de Enero a Junio de 2011. Se incluyeron pacientes adultos en HD durante al menos tres meses que dieran su consentimiento informado. Se excluyeron los pacientes con marcapasos, amputados, hospitalizados y prótesis metálicas. El agua corporal total y el exceso de hidratación se evaluaron con espectroscopia

de bioimpedancia antes de la primera y tercera sesión de diálisis de la semana. Pre-Hd PAS, pre-Hd peso corporal, pre-Hd ACT y pre-Hd OH, se analizaron utilizando el modelo de correlación y regresión lineal de Pearson. Se evaluaron 96 mediciones, 52% eran hombres con edad media 59, 5 años. La correlación entre la PAS pre-Hd y la sobrehidratación pre-Hd fue  $r=0,33$  y agua corporal total  $r=0,15$ , con un valor predicho,  $R^2 = 0,10$  y  $R^2 = 0,14$  respectivamente. Existe baja correlación entre la PAS Pre-Hd con el estado de hidratación pre-Hd y por lo mismo, no es un parámetro confiable para establecer la tasa de ultrafiltración antes de Hd. Sin embargo, el peso corporal Pre-Hd predijo en un 70% el agua corporal total pre-Hd.

**PALABRAS CLAVE: Hemodiálisis; Presión arterial sistólica; bioimpedancia; Velocidad de ultrafiltración.**

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Correspondence to:  
Magdalena Castro C.  
Clínica Las Condes  
Santiago  
CHILE

Email: [sdiclc@clc.cl](mailto:sdiclc@clc.cl)

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