Impact of hemodialysis session on handgrip strength

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Submitted on: 06/30/2015.
Approved on: 07/16/2015.

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DOI: 10.5935/0101-2800.20150072

ABSTRACT

Introduction: Handgrip strength (HGS) is a simple and reliable method with a good predictive clinical value for assessing muscle function of patients undergoing hemodialysis (HD). However, there is no consensus regarding the appropriate moment for performing the HGS measurement since the performance of the HGS can be influenced by fluid, electrolyte and blood pressure changes that affect patients on HD. **Objective:** To investigate the impact of the dialysis session on the HGS in patients undergoing HD. **Methods:** This is a cross-sectional study with 156 patients [57.7% male, median age of 56.5 (42-67) years old, 28.8% diabetes, mean BMI of 24.75 ± 4.5 kg/m^2 and HD vintage of 38 (19.25 to 72.75) months]. Measures of HGS were performed with a dynamometer during the initial minutes of the HD session and at the end of the session. The values obtained were compared with a national standard reference. Clinical, demographic and laboratory data were collected from medical records. **Results:** A significant reduction of HGS was observed after the HD session (28.6 ± 11.4 kg to 27.7 ± 11.7 kg; $p < 0.01$). The prevalence of patients with HGS below the 30th percentile increased from 44.9% to 55.1% ($p < 0.01$). The decrease in blood pressure during dialysis was the only factor associated with the reduction of HGS. **Conclusion:** These findings show that the HD procedure affects negatively the HGS.

Keywords: dialysis; hand strength; muscle strength; muscle strength dynamometer; nutrition assessment.

INTRODUCTION

Patients with chronic kidney disease (CKD) are frequently affected by nutritional status alterations arising from a number of metabolic and hormonal disorders caused by the disease and its treatments.[1] Therefore, nutritional assessment is an element of fundamental importance in the care of these patients and individuals on dialysis in particular. The observation of several parameters, along with objective and subjective methods, have been recommended in nutritional status diagnosis and monitoring.[2] The handgrip strength (HGS) test has been recently added to the roster of clinical practices devised for CKD patients. This simple and reliable test may be used to assess muscle function - from which findings related to muscle mass, nutritional status, and inflammation may be derived - and as a prognostic marker.[3-8]

Different measurement protocols and techniques have been proposed, with variations around the position of the arm, patient posture, number of repetitions, interval between measurements, and the dynamometer type and model.[9] Studies have shown that test results may vary significantly based on the chosen protocol, even when the same individual is tested using different methods.[10,11] Other factors may affect test results when hemodialysis (HD) patients undergo HGS measurement, such as the presence of a vascular access and the time at which the individual is tested - before, after, or between dialysis sessions. The lack of a standardized measurement procedure was pointed out in a systematic review including 11 studies on HGS testing in patients on HD.[12] In six studies the time at which the measurements were made was not mentioned; in two, measurements were made after the HD sessions; and in the other two, just before the start of the dialysis sessions. The authors concluded that although HGS was a useful indicator of muscle mass in nutritional status assessment, a standard measurement protocol should be enforced.

One might speculate that the accumulation of toxic compounds and fluid occurred between dialysis sessions and the variations in water and electrolyte balance and blood pressure levels observed during HD sessions could produce different HGS performance levels when patients are tested before or after dialysis. Despite the many papers showing clear associations between HGS and nutritional markers, only one study looked into the impact of HD on HGS. The authors of this study found no differences in the HGS measured before and after the HD sessions of 43 patients on chronic HD, therefore indicating that the variables related to the dialysis procedure had no impact whatsoever on HGS.[5] It should be noted, however, that these findings were derived from a small sample of selected patients and may not represent the entire population of patients on hemodialysis. Thus, this study aimed to expand the research on the impact of dialysis on the HGS of patients on hemodialysis.

Patients and methods

This cross-sectional study enrolled a convenience sample of patients seen in one hemodialysis center. Enrolled patients had to be 18 years or older, be on HD for at least three months, and could not have physical or cognitive impairments that prevented them from performing handgrip strength tests. The patients underwent standard hemodialysis sessions three times a week with each session lasting for four hours. Clinical, demographic, and workup data were collected from the patients' medical charts. The Human Research Ethics Committee of the Federal University of São Paulo approved the study and the enrolled patients gave informed consent to their participation in the study.

Handgrip strength

Handgrip strength (HGS) was measured using a Jamar (Saehan Corporation, Changwon, South Korea) dynamometer. Patients were asked to stay in a seated position with their arms in adduction and their elbows flexed on a 90-degree angle without touching the char's armrest. Measurements were made with the arm opposite to the arm in which the vascular access had been installed. Patients using catheters had their HGS measured from their dominant arms.

Trained nutritionists advised the patients to apply maximum strength after a verbal cue. Measurements before dialysis were made at least 30 minutes before the start of the session, while measurements after dialysis were made at the end of the session. The maximum value attained after three measurements with intervals of at least one minute between them was considered in the analysis. Measured HGS levels were compared to the HGS of individuals in the 50th percentile of the same gender and age taken from a national reference standard.[13]

Demographic, clinical, and workup data

Demographic, clinical, and workup data were collected from the patients' medical charts. They included age, gender, height, dialysis start date, comorbidities, etiology of chronic kidney disease, blood urea nitrogen levels, and hemoglobin levels. Dialysis effectiveness was assessed based on Kt/V. Pre and post-dialysis systolic and diastolic blood pressure (BP) levels, ultrafiltration, post-dialysis bodyweight, and adverse events occurred during dialysis were recorded the day the patients were tested for HGS. The body mass index (BMI) was calculated based on the patients' weight after hemodialysis and their heights to the square (kg/m^2). Mean BP was calculated according to the following formula: diastolic BP - [(systolic BP - diastolic BP)/3]. The presence of residual renal function was considered when patients had urine outputs greater than 200 mL/day. Interdialytic weight gain (IWG) was the mean value calculated from three consecutive hemodialysis sessions.

Statistical analysis

The distribution of the variables was assessed through the Kolmogorov-Smirnov test. Variables failing to present a normal distribution were standardized using the normal logarithm. Results were expressed in terms of frequencies, mean values and standard deviations, or medians and interquartile ranges, depending on the distribution pattern of the variables. Student's *t*-test, the Mann-Whitney U test, and the chi-square test were used to compare between groups as required. The paired *t*-test and McNemar's test were used to compare findings at two different times - before and after hemodialysis - as required. Pearson's correlation coefficient or Spearman's rank correlation coefficient was used to test the associations between variables. Multiple regression analysis was used to analyze the factors associated with handgrip strength.

Statistical significance was attributed differences with a $p < 0.05$. Statistical analyses were performed with the aid of software package SPSS version 20.0 for Windows (IBM, Chicago, IL).

Results

The handgrip strength (HGS) of 156 patients was measured before and after HD sessions. Almost three-fifths (57.7%) were males, 44.2% were categorized as elderly individuals (age ≥ 60 years), and 28.8% had *diabetes mellitus*. A significant number of patients (42.3%) were overweight (BMI ≥ 25 kg/m^2). The main etiologies of CKD were *diabetes mellitus* (23.1%), systemic hypertension (20.5%), glomerulonephritis (12%), and polycystic kidney disease (10.9%). Unknown causes and other etiologies accounted for 33.3% of the cases. Demographic, clinical, and workup data are presented in Table 1.

Table 1 Demographic, clinical, and workup characteristics (N = 156)

Variable	
Male (%)	57.7
Age (years)	56.5 (42 - 67)
Body mass index (kg/m²)	24.75 ± 4.5
Diabetes Mellitus (%)	28.8
Time on hemodialysis (months)	38 (19.25 - 72.75)
Residual renal function (%)	34.6
Hemoglobin (g/dL)	10.96 ± 1.65
Bloor urea nitrogen (mg/dL)	150.37 ± 37.49
Pre-dialysis weight (kg)	69.09 ± 15.02
Post-dialysis weight (kg)	66.92 ± 14.68
Pre-dialysis mean BP (mmHg)	100.51 ± 11.80
Post-dialysis mean BP (mmHg)	61.73 ± 10.48
Interdialytic weight gain (kg)	2.18 ± 1.0
Ultrafiltration (L)	2.17 ± 1.8
Kt/V	1.38 (1.29 - 1.58)

Data presented as mean value ± standard deviation or median and interquartile range. BP: blood pressure.

Pre-dialysis HGS was 28.6 ± 11.4 kg, presenting a level of adequacy of 90.1 ± 30.0% in relation to the 50th percentile of a healthy population, while 44.9% and 29.5% of the patients had HGS values below the 30th and the 10th percentile, respectively. HGS was greater among male than female patients (33.4 ± 10.7 kg *vs*. 22.2 ± 9.0 kg, respectively; $p < 0.01$), in adult than in elderly patients (32.0 ± 11.5 kg and 24.4 ± 9.7 kg, respectively; $p < 0.01$), and in non-diabetic than in diabetic patients (30.2 ± 11.7 kg and 24.7 ± 9.6 kg, respectively; $p < 0.01$).

Table 2 shows the correlations between pre-dialysis HGS and demographic, clinical, and workup parameters. Negative correlations were observed between HGS and Kt/V (r = -0.42; $p < 0.01$), age (r = -0.35; $p < 0.01$), and time on hemodialysis (r= -0.17; $p < 0.01$); and positive correlations were seen with interdialytic weight gain (r = 0.26; $p < 0.01$), height (r = 0.573; $p < 0.01$), pre-dialysis blood urea nitrogen levels (r = 0.308; $p < 0.01$), and pre-dialysis mean BP (r = 0.194; $p = 0.02$). The multiple linear regression model adjusted for gender, age, and diabetes revealed that only height, blood urea nitrogen levels, and time on hemodialysis were independently associated with pre-dialysis HGS (Table 3). The same results were found when post-dialysis HGS was analyzed.

Table 2 Correlation between pre-dialysis handgrip strength and demographic, clinical, and workup variables

	Handgrip strength	
	r	*p*
Age (years)	-0.349	< 0.01
Height (m)	0.573	< 0.01
Weight (kg)	0.405	< 0.01
Body mass index (kg/m²)	0.064	0.428
Blood urea nitrogen (mg/dL)	0.308	< 0.01
Hemoglobin (g/dL)	-0.113	0.165
Interdialytic weight gain (kg)	0.266	< 0.01
Pre-dialysis mean BP (mmHg)	0.194	0.016
Time on hemodialysis (months)	-0.170	0.04
Kt/V	-0.422	< 0.01

BP: blood pressure.

Table 3 Determining factors for pre-dialysis handgrip strength ($R^2 = 0.532$)

	Handgrip strength		
	B	95% CI	*p*
Gender (female)	-5.69	-9.32; -2.05	< 0.01
Age (> 60 years)	-2.17	-5.13; 0.78	0.15
Diabetes Mellitus	-7.21	-10.40; -4.10	< 0.01
Height (m)	53.77	18.94; 88.60	< 0.01
Bloor urea nitrogen (mg/dL)	0.06	0.02; 0.09	< 0.01
Time on HD (meses)	-1.87	-3.23; -0.50	< 0.01
Kt/V	-5.92	-15.28; 3.45	0.21
Pre-dialysis mean BP (mmHg)	10.71	-0.46; 21.89	0.06

BP: blood pressure.

Mean HGS dropped significantly from 28.6 ± 11.4 kg to 27.7 ± 11.7 kg ($p < 0.01$) after dialysis. HGS adequacy dropped from 90.1 ± 30.0% to 86.9 ± 31.1% ($p < 0.01$). A significant increase in the number of patients with HGS below the 30th percentile was observed after dialysis (pre-dialysis: 44.9%, post-dialysis: 55.1%; $p < 0.01$). No statistically significant differences were seen in the HGS of males vs. females (-0.76 ± 2.73 kg and -1.16 ± 2.97 kg, respectively; $p = 0.38$), adult vs. elderly patients (-1.24 ± 2.97 kg and -0.55 ± 2.62 kg, respectively; $p = 0.05$), diabetic vs. non-diabetic patients (-0.51 ± 2.55 kg and -1.10 ± 2.93 kg, respectively; $p = 0.052$), and patients with vs. without renal residual function (-0.56 ± 2.37 kg and -1.13 ± 3.06 kg, respectively; $p = 0.20$). Mean BP variation was -38.66 ± 13.02 mmHg. Table 4 shows that the variation in HGS was correlated only with the variation in mean blood pressure. Only eight patients (5%) experienced adverse events during hemodialysis - five were hypotensive and three had cramps.

Table 4 Correlation between handgrip strength variation and clinical and workup variables

	HGS variation	
	r	*p*
Ultrafiltration (L)	-0.029	0.719
Interdialytic weight gain (kg)	-0.020	0.802
Bloor urea nitrogen (mg/dL)	-0.047	0.566
Hemoglobin (g/dL)	-0.040	0.623
Weight variation (kg)	-0.041	0.611
Mean BP variation (mmHg)	0.178	0.027
Time on hemodialysis (months)	-0.086	0.285

BP: blood pressure.

Discussion

A significant portion of the individuals included in this study had lower HGS levels when compared to a reference sample containing healthy individuals. Almost half of the patients had HGS below the 30th percentile and about a third of them had HGS below the 10th percentile. Few authors have looked into HGS levels of patients on dialysis.[5,14] A study performed with 43 hemodialysis patients in Rio de Janeiro used the same reference of healthy individuals used in this study and reported that 55.8% of their patients had HGS below the 10th percentile.[5] The prevalence of inadequate HGS levels was even higher (85%) when elderly patients on HD were considered.[14] The reasons contributing to such increase could not be identified in this study, but they might be connected to the reduction of muscle mass and strength resulting from the myriad metabolic, hormonal, and nutritional disorders characteristically seen in individuals treated for CKD. Additionally, symptoms such as fatigue and alterations in the supply/use of oxygen by muscle tissue may further affect the reduction in HGS.[15,16]

As in the general population, HGS levels were lower among women vs. men and in elderly vs. adult patients. Although many factors contribute to HGS, the difference between males and females is mainly due to the lesser amounts of muscle mass generally observed in women, as HGS is correlated with lean body mass even in patients with CKD.[3,5,6] In elderly patients, the lower levels of HGS have been associated not only with decreases in muscle mass, but also with reductions in muscle strength, a condition commonly seen in sarcopenic individuals.[14,17]

Regardless of gender and age, HGS levels were lower in diabetic than in non-diabetic patients. Several factors could contribute to lower HGS in this group of patients such as significant decreases in muscle mass, musculoskeletal complications, and diabetic neuropathy - a condition characterized by sensory and motor disorders conducive to muscle weakness.[18]

Anthropometric and bodily composition parameters such as arm circumference, bodyweight, lean body mass, and the BMI have been associated with HGS in the general population[19,20] and in individuals with CKD.[5-7] In the present study, height was the anthropometric parameter that best correlated with HGS, possibly because of the close relationship between this variable and lean body mass. This finding was in agreement with the reports described in studies enrolling healthy individuals[18] and patients with CKD.[5] However, HGS was not correlated with the BMI, possibly because the impact of height is minimized in this index, making it a better marker for body fat than lean body mass. These findings have been supported by similar studies, in which poor correlations were described between HGS and the BMI in healthy individuals[13,19] or no correlations were seen between them in patients on hemodialysis.[5,6]

Blood urea nitrogen was the only of the workup parameters analyzed in this study to present a positive and independent association with HGS. This finding might somehow seem contradictory, once higher levels of nitrogenous compounds could lead to muscle disorders and negative impacts upon HGS. However, one might speculate that higher blood urea nitrogen levels also reflect greater protein intake and, consequently, better nutritional statuses.

The main purpose of this study was to assess the impact of hemodialysis on HGS, once changes in the water and electrolyte balance and the ensuing consequences could affect an individual's strength. The most common complications observed during hemodialysis were hypotension, affecting 5% to 30% of the patients, and cramps, with an incidence ranging from 5% to 20%.[21,22] Although HGS decreased after dialysis, these adverse events were not very frequently seen in this study, probably because of the low order of interdialytic weight gain and ultrafiltration, which reduced the risk of occurrence of more severe events. However, minor reductions in the mean BP after dialysis were associated with reduced HGS, indicating that even minor decreases in BP seem to negatively affect muscle function.

Fatigue - although not considered in this study - is a complication that may potentially affect HGS. A common symptom among patients particularly after HD sessions, fatigue is characterized by lack of energy, inactivity, and sleepiness. The causes, extent, and severity of this symptom have not been entirely clarified.[23,24] A study suggested that post-dialysis fatigue is more strongly associated with the quick removal of water and solutes during the procedure than with the interaction with the membrane of the dialysis machine or with psychological stress.[25]

Although the reduction in HGS seen after dialysis in this study was of a lower order - a mean of one kilogram - mean adequacy in relation to the 50th percentile decreased dramatically (90.1 ± 30.0% to 86.9 ± 31.1%; $p < 0.01$). Additionally, there was an increase in the number of patients with HGS below the 30th percentile (44.9% before dialysis to 55.1% after dialysis; $p < 0.01$), suggesting that the time at which the measurement is made might lead to underestimated or overestimated HGS adequacy. Therefore, when comparing the prevalence of inadequate HGS from different studies to establish cutoff points associated with clinical endpoints, method standardization - particularly as it relates to the time at which HGS is measured - is of the utmost importance in the assessment of HD patients.

This study presents limitations worthy of consideration. The measurement of HGS soon after the start of dialysis might not accurately represent pre-dialysis measurements. However, given that adverse events tend to occur later during hemodialysis, it is likely that such measurements may not have been affected. This possibility, nonetheless, needs to be tested. Another limitation concerns the measurement of HGS in one single hemodialysis session by different individuals. However, we believe inter-individual variability was mitigated with training and standardization of the HGS measurement technique.

Our findings have shown that hemodialysis negatively affects HGS. HGS tests are designed to measure patient maximum strength. It is likely that HSG measurements in this study were made either before or right after the start of hemodialysis. However, studies including larger numbers of hemodialysis sessions and considering clinical outcomes are required.

Acknowledgements

The authors would like to thank nutritionists Laila Santos de Andrade, Raíssa Antunes Pereira, Flávia Baria Rossini de Souza e Souza, Giovana Sertori, Rebeca Ogg Diamantino, and Gizely Cristina da Silva Moreira for their invaluable contribution with data collection.

This study was supported by the Fundação Oswaldo Ramos, Hospital do Rim.

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