CLINICAL BRIEF

Calf Circumference Predicts Falls in Older Adults on Hemodialysis

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Objective: Older patients with chronic kidney disease (CKD) undergoing maintenance hemodialysis are at a higher risk of falling. However, there is no standard method to screen patients at higher risk. We have evaluated whether calf circumference (CC) measurement would be able to predict falls in this population.

Methods: This is a prospective study that enrolled patients aged ≥65 years on conventional hemodialysis, followed for 6 months. The presence of falls was associated with demographical, clinical, and biochemical data. Reduced CC was set at <34 cm for men and <33 cm for women. We evaluated physical status using Duke activity status index (DASI) and hand grip strength (HGS).

Results: Ninety-one patients were included (age 73.7 ± 5.4 years, 69.2% men, 56% with diabetes). Mean CC was 32.6 ± 3.7 cm, with a high prevalence of reduced CC (61.5%). During the follow-up, 13 falls were identified (1 had a fracture and died). These patients were older and heavier (P = .017 and P = .025, respectively). Most falls occurred in patients with sarcopenic obesity (BMI >27 kg/m^2 plus reduced HGS or reduced CC). In a logistic regression model, reduced CC (hazard ratio (HR) 7.81, confidence interval (CI): 1.13-53.86, P = .037), higher age (HR 1.19, CI: 1.04-1.36, P = .011), and higher body weight (relative risk (RR) 1.13, CI: 1.04-1.22, P = .003) were independently associated with falls in a fully adjusted model.

Conclusion: CC measurement, an easy and nonexpensive tool, was able to predict falls in older patients on HD. Further studies should test the inclusion of CC in a fall risk assessment in older patients on hemodialysis.

Keywords: sarcopenia; chronic kidney disease; Duke activity status index; hand grip strength

Introduction

CHRONIC KIDNEY DISEASE (CKD) affects the worldwide population and is considered a public health problem. With the aging population, there has been an increase in older patients initiating hemodialysis.[1] This population is characterized by frailty, loss of muscle mass, reduced functional capacity, and polypharmacy, factors associated with an increased risk of falls.[2]

About 30% to 40% of elderly people aged ≥65 years fall at least once a year, and these rates tend to increase with advancing age.[3] Falls and fractures, which are considered devastating events in older individuals, lead to high morbidity and mortality rates, reduced functional capacity, institutionalization, and death.[4]

Several tools have been developed to assess the risk of falls in the elderly. However, a standardized tool for use in hemodialysis services, and particularly for older individuals, has not been clearly defined. Calf circumference (CC) measurement is considered a simple and inexpensive way to check muscle mass and has been already used in studies as a simplified way to assess the presence of sarcopenia,[5] which has been associated with falls in the general population.[6] However, so far, CC, as an isolate measurement, has not been applied to evaluate falls in patients on hemodialysis.

The ability to precisely estimate falls risk is critical for patients on hemodialysis, a population with a high risk of fracture. In this regard, even the fracture risk assessment tool (FRAX),[7] a well-validated instrument, does not incorporate falls. Therefore, the aim of the present study was to verify whether elderly patients on hemodialysis with a reduced CC would have a higher risk of falls.

Methods

This is a prospective study with a 6-month followed that included older patients (age higher or equal to 65 years) on maintenance hemodialysis. Patients were recruited from 2 dialysis centers in Sao Paulo, Brazil, in the period between

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Ethical approval: The Local Research Ethics Boards has approved the protocol (#15869219.6.0000.5511).

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June 1st, 2019 and June 30th, 2020. Inclusion criteria were age ≥65 years, on hemodialysis for at least 1 month, ability to read, understand and sign the consent form. Exclusion criteria were current treatment for cancer, amputation, or restriction to bed.

Baseline clinical, demographic, and biochemical data were collected at the first contact and included age, sex, race, body weight, body mass index (BMI), and presence of comorbidities such as diabetes, hypertension, congestive heart failure, and coronary disease. History of previous fall or fracture in the past 6 months was assessed by interview and chart registration. We defined polypharmacy as the use of five or more medications.[8] Laboratory parameters evaluated were hemogram, serum albumin, total calcium, phosphate, 25(OH)-vitamin D, parathyroid hormone (PTH), cholesterol, and creatinine. Secondary hyperparathyroidism was defined as PTH >300 pg/mL, hypovitaminosis D was considered if 25(OH)-vitamin D was below 30 ng/dL.

The Local Research Ethics Boards has approved the protocol, and written consent was obtained from all patients.

Dependent Variable

The main outcome was fall, considered any situation in which the subject suffered an unintentional change in his position to a lower plane. The same researcher followed all patients, by visiting the clinics and contacting patients by phone in a maximal interval of 2 months, for 6 months.

Independent Variable

Calf circumference (CC) was measured by the same trained researcher, using an inelastic measuring tape. Patients were seated, with feet flat on the floor, and knee and ankle at a 90-degree angle. The measurement was taken on the most protruding part of left leg, except for left-handed elderly, where the measurement was carried out on the right leg. Two consecutive measurements were taken, and the average was used for statistical purposes. The time to measure CC was around 2 minutes. The tape zero value was placed below the measured value, the measured values were immediately recorded without rounding. We considered a reduced CC if <34 cm for men and <33 cm for women, as previously described.[5]

Potential Confounders

Hand grip strength (HGS) was evaluated using a portable digital dynamometer (Instrutherm®, Sao Paulo, Brazil). Patients remained seated, the upper limb chosen to be evaluated was positioned at the side of the body with the elbow at a 90° angle, the contralateral limb remained relaxed on the chair arm or on the thigh, the test was performed on the limb without fistula. All adornments present on the hand and wrist of the evaluated limb were removed. With the wrist in a neutral position, thumb facing up, the subject was instructed to feel the instrument well adapted and comfortable in his hand. The participant was encouraged to squeeze as much as possible, when the force value was fixed, the participant was instructed to stop squeezing and the value obtained was recorded immediately. Participant dominance was also recorded. A single measure was taken to avoid the participant's wear and/or stress. We considered normal values >27 kgf for men and >16 kgf for women, as previously described.[9]

Patients were classified into 4 groups according to HGS and body mass index (BMI): normal (normal BMI and HGS), obesity (BMI >27 kg/m^2 and normal HGS), sarcopenia (normal BMI and altered HGS), and sarcopenic obesity (BMI >27 kg/m^2 and altered HGS).

Duke activity status index (DASI) is a 12-item scale that estimates the functional capacity of patients.[10] Each of the 12 items has a specific weight based on the metabolic equivalent of task (MET). Positive responses are summed to get a total score, which ranges from 0 and 58.2. Results correlated with peak oxygen uptake, with higher scores indicating better functional capacity.

Statistical Analysis

Data are presented as mean SD or median (25, 75), as appropriate. The Kolmogorov–Smirnov test was used to determine the normality of data. Associations between 2 categorical variables were verified using the Chi-Square test, or alternatively, Fisher's exact test. Linear associations between numerical variables were assessed using Pearson's correlation. Comparison of means between 2 groups was performed using Student's *t*-test for independent samples or, alternatively, the nonparametric Mann–Whitney test. To assess the variable effects that predict the occurrence of falls, a multivariate logistic regression was performed, and independent variables included were selected from univariate analysis ($P < .01$). Therefore, we included as independent variables age, history of falls, weight, hypertension, and CC (categorized as normal or reduced) in a final model. Diabetes was also modeled since this is a known risk factor for fall.

For all statistical tests, a significance level of 5% was used. Statistical analyzes were performed using SPSS 20.0 statistical software.

Results

During the follow-up, there were 13 falls, which occurred at home (N = 10), in the street (N = 1), and at the hemodialysis unit (N = 2). One fall was associated with fracture and death and all others had no severe consequences. Characteristics of patients and according to the occurrence of falls are shown in Table 1. Most patients were non-White men. Diabetes and hypertension were observed in more than half of the patients. Polypharmacy was found in 68.9% of the samples. Altered CC and HGS were found in 61.5% and 70.3% of patients, respectively. Al least 1/3rd of the samples had previous history of falls. Patients with a reduced CC distinguished from those

Table 1. Characteristics of patients

Parameter	Entire cohort N = 91	Non-fallers N = 78	Fallers N = 13	*P*
Age, years	74 ± 5	73 ± 5	77 ± 4	.017
Male gender, n (%)	63 (69.2)	52 (66.7)	11 (84.6)	.194
Non-White, n (%)	69 (75.9)	61 (78.2)	8 (61.5)	.407
Assistive device, n (%)	30 (33.0)	27 (34.6)	3 (23.1)	.533
Comorbidities, n (%)				
Hypertension	68 (74.7)	61 (78.2)	7 (53.8)	.061
Diabetes	51 (56.0)	43 (55.1)	8 (61.5)	.666
Congestive heart failure	7 (7.7)	6 (7.7)	1 (7.7)	.999
Coronary artery disease	23 (25.3)	18 (23.1)	5 (38.5)	.237
Current drinking, n (%)	3 (3.3)	2 (2.6)	1 (7.7)	.338
Polypharmacy, n (%)	62 (68.9)	53 (68.8)	9 (69.2)	.977
Weight, kg	65.6 ± 12.5	64.4 ± 12.0	72.8 ± 14.0	.025
DASI, sores	20.6 ± 15.7	21.7 ± 15.1	23.8 ± 16.2	.655
Calf circumference, cm	32.6 ± 3.7	32.5 ± 3.8	33.2 ± 2.9	.519
Altered calf circumference, n (%)	56 (61.5)	48 (61.5)	8 (61.5)	.999
HGS, kg	19.1 ± 8.7	18.7 ± 8.9	21.2 ± 7.2	.346
Altered HGS, n (%)	64 (70.3)	53 (67.9)	11 (84.6)	.223
History of previous fall, n (%)	28 (30.8)	21 (26.9)	7 (53.8)	.052
Creatinine, mg/dL	8.4 ± 2.4	8.5 ± 2.4	8.1 ± 2.5	.621
Albumin, g/dL	4.0 ± 0.3	4.0 ± 0.3	4.1 ± 0.2	.699
Cholesterol, mg/dL	148 ± 40	148 ± 38	150 ± 50	.861
Ionized calcium, mg/dL	5.32 ± 1.60	5.32 ± 1.56	5.28 ± 1.68	.956
Phosphate, mg/dL	5.8 ± 1.7	5.8 ± 1.7	5.8 ± 1.2	.875
PTH, pg/mL	388 (234, 614)	383 (238, 615)	405 (198, 581)	.937
Hyperparathyroidism, n (%)	58 (63.7)	50 (64.1)	8 (61.5)	.859
25(OH)-vitamin D	27.0 ± 11.0	27.6 ± 11.0	22.8 ± 9.7	.172
Hemoglobin, g/dL	12.8 ± 11.6	11.7 ± 1.5	11.2 ± 1.4	.315

DASI, duke activity status index; HGS, hand grip strength; PTH, parathyroid hormone.
Values are expressed as mean ± SD, median (25,75) or percentage.

with a normal CC by presenting lower weight (58.7 ± 8.4 *vs.* 76.8 ± 9.7 kg, $P < .001$), lower DASI scores (15.7 ± 12.1 *vs.* 28.5 ± 17.6, $P < .001$), and lower HGS (16.7 ± 8.3 *vs.* 22.7 ± 8.1, $P < .001$).

BMI was <22 kg/m^2, 22-27 kg/m^2, and >27 kg/m^2 in 44.4%, 32.3%, and 23.3% of patients, respectively. Falls occurred in 50% of patients with sarcopenic-obesity, none of the patients with obesity, 9.8% of patients with sarcopenia, and 11.1% of patients with normal BMI and HGS ($P = .002$), as shown in Figure 1. Same results were obtained using reduced CC instead of HGS (data not shown).

Patients identified as fallers to be older and heavier than non-faller patients. Logistic regression analysis identified that reduced CC (OR 7.81, CI: 1.13-53.86, $P = .037$), higher age (OR 1.19, CI: 1.04-1.36, $P = .011$), and higher body weight (OR 1.13, CI: 1.04-1.22, $P = .003$) were independently associated with falls in a model adjusted for history of falls and hypertension (Figure 2). Inclusion of diabetes in the model did not change the results. HGS and DASI scores were not independently associated with falls.

Discussion

The present study investigated whether CC could predict falls in older patients on hemodialysis. The results indicate that CC, higher weight, and age were the main determinants of falls for these patients. Higher body weight as a predictor of falls might reflect sarcopenic obesity.

We found a 14.3% frequency of falls, a rate of 1.7 fall/1,000 patients/year, which agrees with literature data.[11] Higher age, weight, and a reduced CC were independently associated with falls. Of note, these falls occurred in patients classified as sarcopenic obese. Sarcopenia is already recognized as a risk factor for falls. Only one previous study has tested CC to predict falls in elderly patients from the general population.[12] However, to our knowledge, there is no study testing CC measurement as a fall predictor in a hemodialysis setting.

CC is a relatively simple measurement that can be easily performed before the dialysis initiation, and it is not time-consuming. This study proposes the use of this measurement in a greater number of patients so that CC can indeed configure as a tool to predict the risk of falling in patients on dialysis. An additional advantage is to perform CC measurement with patients seated, right before the dialysis initiation. CC measurement is well-validated in older individuals from the general population.[13] For patients on dialysis, CC can add information on health status and allow a more accurate assessment of the nutritional status.[14] Questions on the longitudinal value of this measurement are yet to be answered. Important to mention that, in the presence of pedal edema, the result should be reduced by

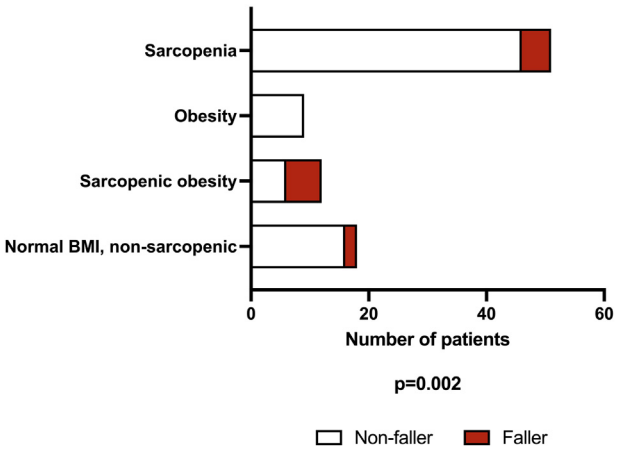

Figure 1. Incidence of falls according to body mass index (BMI) and calf circumference (CC) that classified patients into 4 groups: 1. non-obese and nonsarcopenic, 2. obese, 3. sarcopenic and obese, and 4. sarcopenic. Bars represent the number of patients.

2 cm, as previously recommended,[15] although this has not been tested in a population on dialysis.

Sarcopenia and obesity are common situations in patients with CKD.[16] Whereas sarcopenia yields bad outcomes in patients on dialysis,[17] obesity might confer survival advantage in patients with CKD.[18] However, body mass index, although the most widely used tool to assess obesity, is far from being a perfect measure of adiposity. Sarcopenic obesity is a combination of high body fat with muscle depletion and contribute to bad outcomes more than either of these conditions alone,[17] which was also true for the risk of falls in the current study.

There are some limitations to our study. First, selection bias was inevitable as we did not include patients with severe disabilities. Second, the sample size is small. Third, we had no information about environmental hazards (including hypotension during hemodialysis) and caregiver factors for each patient. Fourth, patients were followed for a short period of time. This study, however, is the first that has tested the CC measurement as a tool to predict falls among patients on hemodialysis.

Further studies are necessary to test whether the measurement of CC, an easy and inexpensive tool, should be incorporated into the clinical practice as a predictor of falls for patients on hemodialysis.

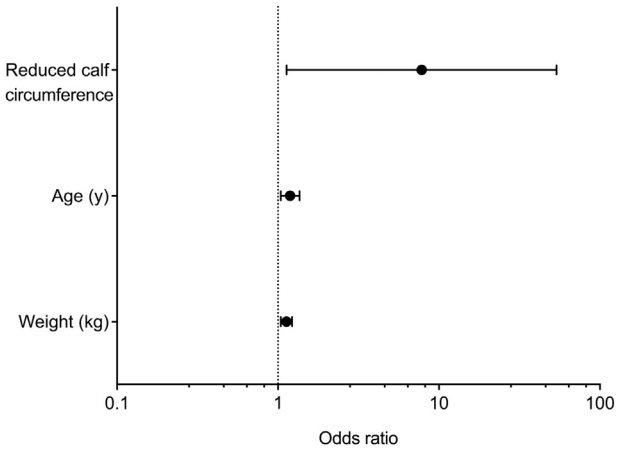

Figure 2. Odds ratio for the risk of falls. Symbols and lines represent hazard ratio and confidence interval.

Practical Application

The measurement of CC is an easy and inexpensive tool that should be incorporate as a screening assay to prevent falls in older individuals on hemodialysis.

Patients with reduced CC (particularly those with high body mass index) should be closely monitored for the risk of falls. Actions should include stimulating regular strength exercises, avoiding hypotensive episodes (adjust medications and ultrafiltration rate during dialysis), avoiding environmental hazards at home (do not use slip shoes, ask for help during baths or when moving positions) and at the dialysis clinic (after dialysis do not go out unaccompanied after dialysis and do not get out of the chair quickly).

Credit Authorship Contribution Statement

Renata G. Rodrigues: Conceptualization, Investigation, Data acquisition, Formal analysis, Writing – original draft, Writing – review & editing. **Maria Aparecida Dalboni:** Writing – review & editing. **Marilia de A. Correia:** Writing – review & editing, Visualization. **Luciene M. dos Reis:** Writing – review & editing. **Rosa M.A. Moyses:** Writing – review & editing, Formal analysis. **Rosilene M. Elias:** Formal analysis, Supervision, Project administration.

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