Adductor pollicis muscle thickness as a predictor of handgrip strength in hemodialysis patients

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ABSTRACT

Introduction: Recently, the adductor pollicis muscle thickness (APMT) has been suggested as a new nutritional marker in several population. **Objective:** In view of the scarce data regarding the use of this marker in CKD patients, we aimed to evaluate APMT and its association with nutritional parameters in patients on hemodialysis. **Methods:** We evaluated 73 hemodialysis patients (52.3 ± 17 years, without residual renal function). The APMT was assessed in the non vascular access arm by means of skinfold caliper. Body composition (bioelectrical impedance), handgrip strength (HGS, dynamometer), nutritional status (subjective global assessment), and laboratory parameters (creatinine, total protein and albumin) were also evaluated. **Results:** Subjects with APMT values above the median were in greater proportion black/brown, younger and had higher HGS. The APMT correlated positively with HGS, albumin and body cell mass (%), and negatively with age. In the linear regression analysis adjusted for sex, age and length on hemodialysis, APMT was independently associated with HGS. **Conclusion:** APMT was able to predict HGS in hemodialysis patients, suggesting APMT as a promising nutritional marker in this population.

Keywords: kidney failure, chronic; muscle strength dynamometer; nutritional assessment; nutritional status.

INTRODUCTION

Chronic kidney disease (CKD) is characterized by high incidence and prevalence rates. The latest census produced by the Brazilian Society of Nephrology revealed that approximately 91,000 patients are on dialysis in Brazil, and that 90% of them are on hemodialysis.[1] A number of factors connected to CKD and dialysis may contribute to the onset of protein-energy malnutrition (PEM). Among them are conditions related to low food intake, such as anorexia; the presence of symptoms of uremia; use of medication; social and psychological issues; factors related to catabolism resulting from inflammation; secondary hyperparathyroidism; metabolic acidosis; and loss of nutrients to the dialysis bath. The high prevalence of PEM in patients on hemodialysis has been established in the literature.[2-5] Nutritional assessment is indispensable in the management of hemodialysis patients, as PEM and morbimortality are strongly correlated in this population. Additionally, it may improve patient prognosis.[6]

In this context, lean body mass is an important marker of the patient's nutritional status, with well-established associations with the clinical outcomes of hemodialysis patients.[5,7-10] The most frequently used methods to determine lean mass in clinical settings include arm muscle circumference (AMC), arm muscle area (AMA), bioelectrical impedance analysis (BIA), and the physical examination of the Subjective Global Assessment (SGA) tool.[11-15] However, given that 73% of the body's lean mass is water, these measurements may be affected by water balance disorders often seen in patients on hemodialysis. Therefore, assessment of body lean mass stands as one of the most significant challenges for health care workers in this area.

Hand grip strength has been recently recognized as a good marker for muscle mass in CKD patients.[16,17] One of the main advantages of this marker is that it is not affected by the hydration status of the patient. The correlation between grip strength, reduced appetite,[18] and death[19] has been established for patients on dialysis. Recently, adductor pollicis muscle thickness (APMT) has been suggested as a promising marker of muscle mass for some clinical conditions.[20-23] The adductor pollicis muscle is the only muscle that allows direct thickness assessment as it is anatomically well defined and flat in shape.[24] Population studies have described the use of the APMT in muscle function tests.[25-28] However, few have looked into it as a marker of nutritional status.

Given the promising role the APMT may have as a nutritional marker and the few studies considering this potential marker on populations with CKD, this study aimed to test the APMT as a nutritional marker for patients on hemodialysis.

Methods

This cross-sectional study included 73 patients on hemodialysis treated at the Oswaldo Ramos Foundation (FOR) at the Paulista School of Medicine of the Federal University of São Paulo between July and November of 2011. Patients on hemodialysis for three months or longer and aged 18 or older were invited to join the study. The following exclusion criteria were adopted: presence of residual renal function (urinary output > 200 mL), amputation of lower or upper limbs, or presence of conditions that precluded APMT measurement.

The study protocol was approved by the Research Ethics Committee of the Federal University of São Paulo. All enrolled patients signed an informed consent term.

In addition to hand grip strength and APMT, the following variables were considered: SGA, BIA, lab workup results, and anthropometric parameters such as the body mass index - BMI (kg/m^2), brachial circumference (BC), tricipital skinfold thickness (TST), arm muscle circumference (AMC) and arm muscle area (AMA). All measurements were made by two trained nutritionists after the patients had undergone hemodialysis (any session of the week); arm measurements were made on the arm opposite to the vascular access.

Subjective global assessment

SGA was based on the assessment of patient clinical history and physical examination findings.[15] Clinical history covered the evaluation of body weight variation, food intake, gastrointestinal symptoms, and the patient's physical condition. Physical examination was used to subjectively assess subcutaneous fat reserves and muscle mass in specific sites. Each of the categories was given scores from one to seven, with higher scores attributed to better nutritional statuses. In the end, patients were categorized as severely malnourished (scores from one to two), mildly to moderately malnourished (scored from three to five), or normally nourished (scores from six to seven).[29]

Bioelectrical impedance analysis

The assessment of body composition through bioelectrical impedance analysis (BIA) was carried out on a single-frequency (50 kHz) 800-mA tetrapolar device (RJL Systems) after patients had undergone hemodialysis. Subjects were positioned in horizontal dorsal decubitus with upper limbs spread away from the chest. In a setting with four impedance plethysmography electrodes, an imperceptible current was passed through the distal electrodes in the hand and foot of the patient so that voltage was captured by the proximal electrodes. The electrodes were placed above the dorsum of the hand on the opposite side of the arm with the vascular access and in the midline above the dorsum of the foot on the same side close to the à metatarsophalangeal joint (MTPJ). This non-invasive procedure takes about three minutes to be completed.

Resistance, reactance, and phase angle values were derived from BIA. Software program Fluids was used to estimate lean mass and body cell mass.

Hand grip strength

A dynamometer (Baseline®) was used to assess the hand grip strength of the upper limbs without vascular access in patients fitted with arteriovenous fistulae or of the dominant upper limbs in patients given catheters. Patients were seated with one arm up forming an angle of 90º degrees with the forearm. Measurements were repeated three times and the highest strength reading was chosen. Hand grip strength was not considered for patients affected by tendinitis or other hand conditions that could limit their performance in the test.

Adductor pollicis muscle thickness (APMT)

APMT measurements were made with patients in a seated position. Subjects were asked to keep their arms bent at an angle of approximately 90º degrees in relation to the forearm, with the arm sat on the thigh and the hand on the knee. Patients were advised to leave their hands loose and thumbs away from the other fingers to form an angle of 90º degrees in relation to the index finger (Figure 1). A skinfold caliper set at a constant pressure of 10 g/mm^2 was used to pinch the muscle in the center of an imaginary triangle formed by the patient's index finger and thumb. The mean value of three measurements performed in the same day was considered for further analysis.

Figure 1. APMT measurements.

Lab workup

Routine lab workup (blood urea, creatinine, and albumin) was carried out on the day of the first hemodialysis session of the week with patients in a fasting regimen. Tests were processed at the Kidney and Hypertension Hospital Laboratory - Oswaldo Ramos Foundation/Federal University of São Paulo (UNIFESP/EPM).

Protein intake was estimated through the protein equivalent of total nitrogen appearance (PNA), as recommended by the K/DOQI.[30] Dialysis adequacy was calculated based on Kt/V.

Statistical analysis

Results were expressed in the form of mean values and standard deviations, medians and interquartile ranges, or ratios. Comparisons between independent samples used Student's *t*-test for continuous variables following a normal distribution, and the Chi-square test for categorical variables. Pearson's correlation coefficient was used to test possible correlations between variables. Linear regression was used to test the independent correlation between APMT and hand grip strength. Statistical significance was attributed to events with $p < 0.05$. Statistical analysis was performed on software SPSS (Statistical Package Social Sciences) version 18.0 for Windows (Illinois, MA, USA).

Results

Seventy-three patients, 57.5% males, with a mean age of 52.3 ± 17 years were included in the study. Table 1 shows demographic, clinical, and nutritional data of the studied population separated by gender. Adequacy values for AMC, AMA, resistance, and Kt/V were higher in females. Males had significantly higher values for cell mass (%), hand grip strength, and serum creatinine. APMT and malnutrition status as assessed in the SGA were not significantly different when genders were compared.

Table 2 describes the characteristics of patients above and below median APMT (10 mm). Individuals with greater APMT were mostly black or brown, younger, and had higher hand grip strength scores. SGA-based malnutrition n were not statistically different when both groups were compared.

APMT was positively correlated with hand grip strength (Figure 2), serum albumin, cell mass (%), reactance, phase angle, and negatively correlated with age (Table 3). No correlation was found between APMT and serum creatinine, SGA, and traditional anthropometric parameters. Linear regression adjusted for gender, age and time on hemodialysis indicated that APMT was a predictor for hand grip strength (Table 4).

Discussion

APMT was identified as a predictor for hand grip strength in the hemodialysis patients enrolled in this study regardless of age, gender, and time on dialysis. The correlation between APMT and hand grip strength had been described for non-healthy individuals,[20,31] but not for patients with CKD.

APMT has been recently considered as a nutritional parameter for both healthy and non-healthy individuals with other diseases. Lameu *et al.*[24] and Gonzalez *et al.*[23] found greater APMT values in healthy subjects aged between 30 and 65 years. In this study, APMT values below the median were seen in older patients; APMT was inversely correlated with age. Authors in general have reported good correlations between APMT and traditional anthropometric parameters such as BC, AMC, TST, and BMI.[20-22] However, in our study the APMT was not correlated with any of these parameters. This may have occurred for a number of reasons. First, even though anthropometric values have well-defined standard values, water balance disorders frequently seen in patients on hemodialysis may compromise

Table 1 Demographic, clinical, and nutritional characteristics of hemodialysis patients

Variables	Total (n = 73)	Males (n = 42)	Females (n = 31)	*p*
Age (years)	52.3 ± 17.0	53.3 ± 16.3	50.9 ± 18.1	0.56
Blacks/browns [n (%)]	28 (38.4)	17 (40.5)	11 (35.5)	0.81
Time on HD (months)	56 (28-110.6)	56 (32.2-100.2)	56 (23-121)	0.70
Diabetes [n (%)]	15 (21.9)	12 (28.6)	4 (12.9)	0.15
Previous hospitalization [n (%)]	9 (12,3)	4 (9,5)	5 (16.1)	0.48
Kt/V	1.39 ± 0.27	1.30 ± 0.26	1.51 ± 0.23	< 0.05
Creatinine (mg/dL)	11.4 ± 3.2	12.2 ± 3.2	10.4 ± 3.0	< 0.05
Total protein (g/dL)	6.5 ± 0.5	6.5 ± 0.5	6.6 ± 0.6	0.90
Albumin (g/dL)	3.8 ± 0.3	3.9 ± 0.3	3.8 ± 0.3	0.25
PNA (g/Kg/day)	1.16 ± 0.30	1.19 ± 0.32	1.13 ± 0.26	0.33
BMI (Kg/m^2)	23.5 ± 4.5	24.2 ± 4.7	22.6 ± 3.9	0.22
CBW/IBW (%)	107.9 ± 18.2	112.3 ± 19.2	101.8 ± 15.0	0.30
BC%	91.5 ± 15.8	90.9 ± 15.7	92.4 ± 16.1	0.68
AMC%	92.6 ± 13.4	88.8 ± 11.2	97.7 ± 14.5	< 0.05
AMA%	87.4 ± 25.7	80.0 ± 20.3	97.4 ± 29.1	< 0.05
MM%	74.4 ± 9.5	78.6 ± 7.4	68.4 ± 9.0	< 0.05
Cell mass (%)	33.1 ± 4.8	35.3 ± 4.1	30.0 ± 4.0	< 0.05
Reactance (Ω)	59.4 ± 15.31	57.7 ± 13.4	61.7 ± 17.6	0.28
Resistance (Ω)	610.7 ± 84.0	580.2 ± 69.4	653.5 ± 85.0	< 0.05
Phase angle (°)	5.5 ± 1.3	5.7 ± 1.2	5.4 ± 1.4	0.29
Hand grip strength (Kg)	21.0 ± 11.9	25.3 ± 11.6	15.2 ± 9.8	< 0.05
APMT (mm)	10.0 ± 4.5	10.8 ± 4.9	9.0 ± 3.7	0.08
SGA (normal)	38 (51.4)	21 (50)	17 (54.8)	
SGA (mild/moderate malnutrition)	34 (45.9)	21 (50)	13 (41.9)	0.43
SGA (severe malnutrition)	1 (1.4)	0	1 (3.2)	

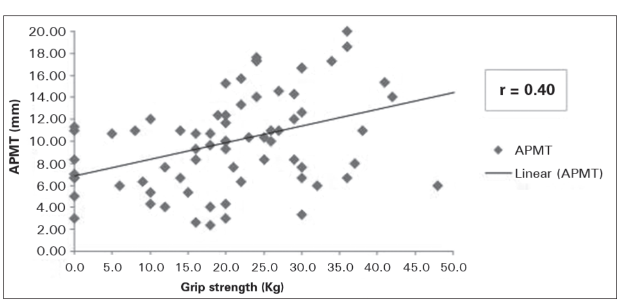
HD: hemodialysis; BMI: body mass index; CW/IW%: percent ratio current body weight vs. ideal body weight; BC%: brachial circumference percent adequacy; AMC%: arm muscle circumference percent adequacy; AMA%: arm muscle area percent adequacy; MM%: muscle mass percentage; PNA: protein equivalent of total nitrogen appearance; SGA: subjective global assessment. Continuous variables were expressed in the form of mean values and standard deviations or medians and extremes.

TABLE 2 PATIENT CHARACTERISTICS ACCORDING TO ADDUCTOR POLLICIS MUSCLE THICKNESS (APMT)

Variables	APMT ≤ 10 mm (n = 37)	APMT > 10 mm (n = 36)	*p*
Age (years)	57.7 ± 15.21	46.7 ± 17.2	< 0.05
Blacks/browns [n (%)]	9 (24.3)	19 (52.8)	< 0.05
Time on HD (months)	44 (8-360)	56.5 (11-312)	0.85
Diabetes [n (%)]	11 (29.7)	5 (13.9)	0.16
Previous hospitalization [n (%)]	4 (10.8)	5 (13.9)	0.74
Kt/V	1.43 ± 0.29	1.34 ± 0.23	0.12
Creatinine (mg/dL)	10.8 ± 3.3	12.0 ± 3.0	0.08
Total protein (g/dL)	6.6 ± 0.5	6.5 ± 0.5	0.36
Albumin (g/dL)	3.8 ± 0.3	4.0 ± 0.3	0.07
PNA (g/Kg/day)	1.16 ± 0.28	1.16 ± 0.31	0.94
BMI (Kg/m^2)	23.8 ± 4.3	23.3 ± 4.7	0.64
CBW/IBW (%)	108.8 ± 17.2	106.9 ± 19.3	0.65
BC%	92.4 ± 15.4	90.6 ± 16.3	0.62
AMC%	93.2 ± 10.4	91.9 ± 16.0	0.70
AMA%	87.8 ± 19.6	87.0 ± 31.1	0.89
MM%	73.3 ± 8.0	75.4 ± 10.8	0.35
Cell mass (%)	31.7 ± 4.2	34.4 ± 5.0	< 0.05
Reactance (Ω)	55.4 ± 15.1	63.4 ± 14.6	< 0.05
Resistance (Ω)	617.1 ± 89.1	604.4 ± 79.2	0.53
Phase angle (°)	5.1 ± 1.3	6.0 ± 1.2	< 0.05
Hand grip strength (Kg)	17.7 ± 11.7	24.4 ± 11.3	< 0.05
SGA (normal)	20 (54.1)	18 (50)	
SGA (mild/moderate malnutrition)	16 (43.2)	18 (50)	0.55
SGA (severe malnutrition)	1 (2.7)	0	

HD: Hemodialysis; BMI: Body mass index; CW/IW%: percent ratio current body weight vs. ideal body weight; BC%: brachial circumference percent adequacy; AMC%: arm muscle circumference percent adequacy; AMA%: arm muscle area percent adequacy; MM%: muscle mass percentage; PNA: Protein equivalent of total nitrogen appearance; SGA: subjective global assessment. Continuous variables were expressed in the form of mean values and standard deviations or medians and extremes.

Figure 2. Correlation between adductor pollicis muscle thickness and hand grip strength.



the measurements and the interpretation of such findings in this population.[32] Additionally, there is substantial error in the reproducibility of anthropometric measurements. Studies have shown that skinfold thickness measurement inter-rater variability may be as high as 22.6%.[33] In arm circumference measurements, inter-rater variability has been reported to be of approximately 4.7%.[34]

APMT and SGA correlation was reported in a study carried out on a population of critical patients.[22] Such correlation was not observed in this study. However, it is important to mention that the prevalence of malnutrition as categorized by the SGA and reported by these authors differed significantly from what we found in our study (75.8% *vs*. 47.3%). This disparity, along with the demographic and clinical differences between the studied populations and the size of the sample, may have weakened the correlation between APMT and SGA.

The authors of a recent study on hemodialysis patients found positive correlations between APMT and BMI, BC, AMC, creatinine levels, albumin levels, cell mass (%), and phase angle, and

Table 3	**Correlations between adductor pollicis muscle thickness (APMT) and studied variables**	
Variables	r	*p*
Age (years)	-0.321	< 0.05
Time on HD (months)	0.039	0.74
Kt/V	-0.228	0.05
Creatinine (mg/dL)	0.195	0.10
Total protein (g/dL)	-0.070	0.56
Albumin (g/dL)	0.273	< 0.05
PNA (g/Kg/day)	-0.066	0.58
BMI (Kg/m^2)	-0.106	0.37
CBW/IBW (%)	-0.110	0.35
BC%	-0.065	0.58
AMC%	-0.078	0.51
AMA%	-0.063	0.59
MM%	0.207	0.08
Cell mass (%)	0.403	< 0.05
Reactance (Ω)	0.271	< 0.05
Resistance (Ω)	-0.152	0.20
Phase angle (°)	0.383	< 0.05
Hand grip strength (Kg)	0.400	< 0.05
SGA (1-7)	-0.017	0.89

HD: Hemodialysis; BMI: Body mass index; CW/IW%: Percent ratio current body weight *vs.* ideal body weight; BC%: brachial circumference percent adequacy; AMC%: Arm muscle circumference percent adequacy; AMA%: arm muscle area percent adequacy; MM%: muscle mass percentage; PNA: Protein equivalent of total nitrogen appearance; SGA: Subjective global assessment.

Table 4	**Análise de regressão linear utilizando força de preensão manual como variável dependente (R^2 = 0.20)**		
Variables	Coefficient	95% CI	*p*
Gender	0.29	4.82 to 13.77	< 0.05
Age	-0.23	-0.37 to -0.10	< 0.05
Time on HD	-0.04	-0.07 to -0.01	< 0.05
APMT	0.59	0.07 to 1.11	< 0.05

a negative correlation with resistance.[35] Positive correlations between APMT and albumin levels, phase angle, and cell mass (%) and a negative correlation between APMT and resistance were described in this study. None of these studies found correlations between APMT and lean mass as assessed in BIA. In patients without CKD, the correlation between APMT and BIA muscle mass was described by Oliveira & Frangella (r = 0.5315).[20] BIA is known to be a practical method used to assess body composition, and the fact that it estimates the amount of body water, in addition to lean mass and fat, has favored its use among nephrologists.[36] Nonetheless, over or underestimation of lean mass due to water balance disorders, particularly in dialysis patients, and the lack of formulae to predict lean mass of this specific population, are the main limitations affecting BIA. Therefore, BIA-derived parameters that eliminate mathematical error such as reactance, cell mass, and phase angle have attracted more attention.[13] There is evidence that reactance and phase angle may be used to predict risk of hospitalization and death for dialysis patients.[37,38] The authors of this study and Oliveira *et al.*[35] found strong correlations between these parameters and APMT.

Muscle mass reduction is seen as the most important parameter to detect PEM.[39] Muscle function has been given significant attention in nutritional assessment, not only due to the impact malnutrition produces upon it, but mainly for its use as a predictor of change in body composition.[25,40] In this sense, methods that take muscle function into account have become useful tools in the clinical management of patients with CKD.[17,25,40]

Hand grip strength measured with a dynamometer is an established method to assess the muscle function of patients with CKD.[10,16,17,19,41] Hand grip strength tests are considered to be practical, objective, affordable, and non-invasive. Additionally, these tests are not impacted by water balance disorders commonly seen in populations on dialysis. Studies have described a good correlation between hand grip strength and body composition parameters assessed through dual-energy X-ray absorptiometry (DEXA)[16] and SGA.[10] Several authors have also indicated that hand grip strength is a good predictor for morbidity and mortality in various populations. Leal *et al.*[17] studied patients on hemodialysis and found that 55.8% of the individuals had reduced muscle function; female patients had hand grip strength values below the 10th percentile and lower values for BC, AMC, and AMA (against healthy adults for gender and age from Rio de Janeiro). As previously mentioned, the correlation between hand grip strength and APMT was observed in studies carried out with subjects submitted to surgery (r = 0.46; $p < 0.001$) and stroke patients (r = 0.56; $p = 0.0024$).[20,31] This study is the only up to this moment to assess this correlation in dialysis patients.

Recently, Bragagnolo *et al.*[31] observed a correlation between APMT and higher risk of death and postoperative complications in patients submitted to gastrointestinal surgery. APMT was used in patients scheduled to undergo heart surgery to predict clinical outcomes such as sepsis, length of hospitalization, and death.[42] A recent study showed that APMT was correlated with higher risk of hospitalization in the six-month follow-up of patients on dialysis.[35]

APMT limitations include the lack of reference values. Additionally, the inter-rater and test-retest reproducibility of APMT measurements has not been evaluated, which further reinforces the importance of having trained personnel perform measurements.

To sum up with, APMT served as a good predictor for hand grip strength in hemodialysis patients, and appears to be a promising marker for patient nutritional status. However, more studies are required to consolidate the role of APMT as a nutritional status marker for CKD patients and substantiate its role as a predictor of morbidity and mortality in this population.

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