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Applied nutritional investigation

Adductor pollicis muscle and nutritional status in heart failure patients: Is there an association?

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ABSTRACT

Objectives: Adductor pollicis muscle thickness (APMT) has been used as a simple index for muscle mass for the assessment of nutritional status among hospitalized patients to identify malnutrition. The aim of this study was to evaluate the association between APMT and nutritional status in clinical patients diagnosed with congestive heart failure (CHF).

Methods: APMT was measured in 500 patients with CHF on the dominant side. Nutritional status was assessed means of by the Subjective Global Assessment (SGA). Functional classification was performed according to guidelines provided by the New York Heart Association (NYHA), which establishes four categories of CHF severity. Poisson regression was used to verify the association of APMT, malnutrition, and severity of CHF. $P \leq 0.05$ was considered statistically significant.

Results: The malnutrition prevalence varied from 1.5% in patients with functional class I CHF to 96.2% in patients classified as functional class IV ($P \leq 0.001$). In both sexes, APMT values were significantly lower in patients who were malnourished ($P < 0.001$). The proportion of patients with CHF and malnutrition was higher among women than men (47.2 versus 37.4%, $P = 0.027$). Malnutrition was slightly more common among patients ≥60 y of age compared with other age groups (48.3%, $P \leq 0.001$). APMT is a significant protective factor for malnutrition even after controlling for sex, age, body mass index, and CHF functional class.

Conclusions: Malnutrition is highly prevalent among patients with CHF and is associated with functional class. APMT may be used as a simple index for muscle mass for the assessment of nutritional status in these patient populations, and is also associated with malnutrition in these patients, even after controlling for other risk factors.

Introduction

Muscle mass is an important nutritional status assessment parameter [1]. Insufficient protein intake, catabolism associated with inflammation, or a combination of both, leads to loss of muscle mass [2], which is associated with negative outcomes such as loss of muscle function. Muscle function loss leads to decreased mobility, difficulty functioning independently, and the development of sarcopenia [3]. Indeed, significant loss of muscle mass has been related to decreased quality of life, longer hospitalizations, and higher mortality [4].

Recent studies on congestive heart failure (CHF) reported an association between loss of muscle mass and poor nutritional status. Patients with CHF and loss of muscle mass also had increased risk for clinical complications [5]. In patients with CHF, loss of muscle mass may reflect inappropriate diet, malabsorption, or metabolic changes caused by the disease itself [6].

Recent technological innovations in magnetic resonance, computer tomography, ultrasonography, x-ray, and ulnar nerve stimulation have facilitated the evaluation of muscle mass and its functionality. However, although these methods are reliable, they are expensive, have limited accessibility, and are highly technically complex [1]. To supplement these traditional anthropometric measures, adductor pollicis muscle thickness (APMT) measurement has been developed as a new muscle mass assessment tool [7–10].

APMT has been used as an index for muscle mass and undernutrition [9]. This technique is inexpensive, minimally invasive, and painless. Its simplicity allows clinicians to obtain measurements with a low margin of error [10]. However, to our knowledge, few studies in

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the scientific literature have examined the association between APMT, as a marker of muscle mass, and nutritional status among hospitalized patients. To our knowledge, no study published to date has investigated the issue in patients with CHF. The objective of this study was to evaluate the association between APMT and nutritional status in clinical patients diagnosed with CHF.

Materials and methods

This cross-sectional observational study was performed at the Institute of Cardiology in Porto Alegre, Brazil, from August 2016 to October 2017. The study ultimately included 1104 patients diagnosed with CHF. All patients included in the study were >18 y of age. For logistic reasons, only patients admitted on Mondays, Wednesdays, or Fridays were included. Exclusion criteria were hospitalization in the intensive care unit (ICU), candidacy for emergency surgery, prognosis for survival <90 d, inability to undergo anthropometric assessments, presence of edema, difficult venous access, or other obstacles to the assessment of handgrip strength. Considering a prevalence of malnutrition ranging from 33% to 38% [11], expected loss to follow-up, and adjustments for confounding factors, sample size was estimated as 500 patients. Ultimately, we included 500 clinical patients diagnosed with CHF (Fig. 1). All study participants provided signed informed consent. The study was approved by the institute's Committee on Ethics in Research.

All participants were asked to complete a semi-structured questionnaire, which included questions about the following variables: education (in years), marital status, current weight (kg) and height (cm), as well as self-reported diagnosis with systemic arterial hypertension, chronic renal failure, chronic obstructive pulmonary disease (COPD), and/or diabetes mellitus. Body mass index (BMI) was calculated using reported weight and height (kg/m^2) and classified according to standards provided by the World Health Organization [12]. Sex and skin color were noted and recorded by the interviewers.

Socioeconomic status (SES) was evaluated according to the Associação Brasileira de Empresas de Pesquisa (ABEP) [13], which considers certain material possessions, degree of education achieved by the head of household, and employment of a domestic servant. Participants were stratified based on SES into five categories, with (A) representing individuals at the highest level of SES and (E) representing the group with the lowest level of SES.

To evaluate nutritional status, Subjective Global Assessments (SGAs) [14,15] were performed by two experienced professionals. Each patient was classified as well nourished (SGA-A), moderately or suspected to be malnourished (SGA-B), or severely malnourished (SGA-C). SGA-B and C patients were considered malnourished.

Bilateral assessments of APMT were performed with A Lange skinfold calipers (Beta Technology, Santa Cruz, CA, USA) [7]. The adductor muscle was pinched with the skinfold caliper at the vertex of an imaginary triangle formed by the thumb and the extended index finger, with continuous pressure of 10 g/mm. Three measurements were averaged to obtain adductor muscle thickness.

Dominant APMT was measured on the right hand of right-handed individuals and on the left hand of left-handed individuals [5]. APMT values were compared with reference values for healthy individuals [16]. Values below the fifth percentile (P^5) of reference values adjusted for sex and age (17.3 mm for men and 13 mm for women) were considered as low APMT.

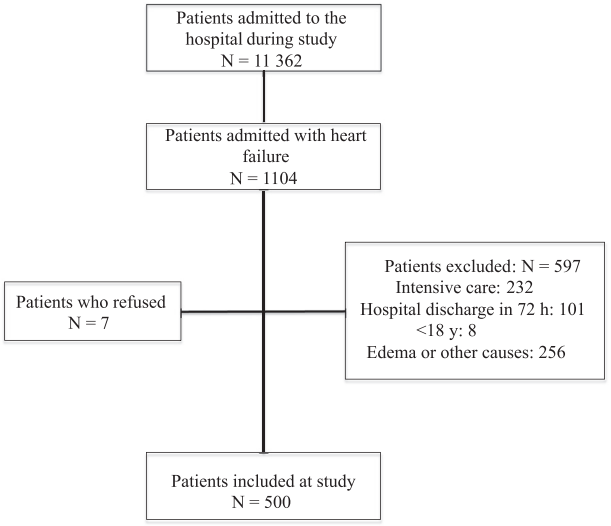

Fig. 1. Flowchart of the patients included in the study.

Ejection fraction (EF) was also measured. Patients were classified as having low EF if EF was ≤40%. Functional class (FC) was performed according to guidelines provided by the New York Heart Association (NYHA), which establish four categories of CHF severity (FC I–IV) [17] .

Statistical analysis

Statistical analyses were performed with STATA software, version 14 (StataCorp, College Station, TX, USA). Descriptive analyses were performed for the sample distribution of sociodemographic variables, anthropometrics, nutritional information, and clinical characteristics.

For bivariate analysis, Student's *t* test was used to compare APMT values according to nutritional status and sex. The χ^2 test was used to verify the association between malnutrition and the studied variables. Poisson regression was used to verify the association of APMT with malnutrition, after adjustments for possible confounding factors such as sex, age, weight, height, BMI, and severity of CHF. $P \leq 0.05$ was considered statistically significant.

Results

In this study, 500 patients with heart dysfunction were evaluated. Their general characteristics are described in Table 1. The sample was similar according to sex distribution (50.8% male); 75.8% were ≥60 y of age; 82.2% were white. Table 2 presents the nutritional information and clinical characteristics for the study population (total and according to sex). Most (53.6%) patients were overweight or obese and men were more overweight and obese than women ($P = 0.004$). The results showed that 42.2% had some level of malnutrition: 24.4% had moderate malnutrition (SGA-B); 17.8% had severe malnutrition (SGA-C). After adjustment for sex, 12.6% presented APMT values below P^5 for the reference population. Most of the patients included in the study had hypertension (70.0%), and COPD was more prevalent in men ($P = 0.032$).

When the NYHA's FC for CHF was applied, 56.8% of patients were classified as FC III or IV, and women had a higher severity than men ($P = 0.001$). Approximately one-third of the sample (32.9%) presented EF ≤40%.

In both men and women, APMT values were significantly lower in those who were undernourished ($P < 0.001$; Table 3).

Table 4 presents the factors significantly associated with nutritional status in patients with CHF. The proportion of patients with CHF and malnutrition was higher among women than men (47.2 versus 37.4%, $P = 0.027$). Malnutrition was slightly more common among patients ≥60 y of age compared with other age groups (48.3%, $P \leq 0.001$) and those with lower SES (C and D/E, 47.5% and 46.9%, respectively). There was also a significant association between malnutrition

Table 1
Sociodemographic characteristics of patients with CHF (N = 500)

Characteristics	n (%)
Sex	
Women	246 (49.2)
Men	254 (50.8)
Age, ty	
18–29.9	15 (3.0)
30–59.9	106 (21.2)
≥60	379 (75.8)
Race	
White	411 (82.2)
Non-white	89 (17.8)
Socioeconomic status*	
A	25 (5.1)
B	202 (41)
C	233 (47.4)
D/E	32 (6.5)

CHF, congestive heart failure.
*Economic status according to Brazilian Association of Research Companies questionnaire, in which the levels A and B are considered high class, C is middle class, and D and E are low class.

Table 2
Nutritional and clinical characteristics of patients with CHF according to sex (N = 500)

Characteristics	Total N (%)	Women n (%)	Men n (%)	*P*-value*
BMI, kg/m^2				0.004
<18.5	16 (3.2)	11 (4.5)	5 (2)	
18.5–24.	216 (43.2)	198 (44.2)	107 (42.1)	
25–29.9	145 (29)	55 (22.4)	90 (35.4)	
≥30	123 (24.6)	71 (28.9)	52 (20.5)	
SGA				0.076
Well-nourished (SGA-A)	289 (57.8)	130 (52.8)	159 (62.6)	
Moderate malnourished (SGA-B)	122 (24.4)	69 (28.1))	53 (20.9)	
Severe malnourished (SGA-C)	89 (17.8)	47 (19.1)	42 (16.5)	
APMT				
≥P^5	437 (87.4)	212 (86.2)	225 (88.6)	0.418
<P^5	63 (12.6)	34 (13.8)	29 (11.4)	
Comorbidities†				
Diabetes	144 (28.8)	61 (24.8)	83 (32.7)	0.052
Hypertension	350 (70)	176 (71.5)	174 (68.5)	0.458
COPD	56 (11.2)	20 (8.13)	36 (14.2)	0.032
Chronic renal failure	66 (13.2)	26 (10.6)	40 (15.8)	0.087
CHF functional class				0.001
I	67 (13.4)	19 (7.7)	48 (18.9)	
II	149 (29.8)	71 (28.9)	78 (30.7)	
III	125 (25)	72 (29.3)	53 (20.9)	
IV	159 (31.8)	84 (34.1)	75 (29.5)	
EF, %				0.090
≤40	164 (32.9)	72 (29.4)	92 (36.2)	
41–49	50 (10)	21 (8.6)	29 (11.4)	
≥50	285 (57.1)	152 (62)	133 (52.4)	

BMI, body mass index; APMT, adductor pollicis muscle thickness; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; EF, ejection fracture; SGA, Subjective Global Assessment.
*Pearson χ^2 test between sexes.
†Patients may present >1 comorbidity and sum exceeds 100%.

and BMI: 93.7% of patients with BMI <18.5 kg/m^2 were undernourished. APMT values below P^5 were significantly associated with malnutrition as well: 90.5% of patients with low APMT values were undernourished compared with 35.2% of those with normal APMT. Higher CHF FC was associated with a higher prevalence of malnutrition. The prevalence of malnutrition varied from 1.5% in patients with FC I CHF to 96.2% in patients classified as FC IV ($P \leq 0.001$).

After adjusting the results for sex and age with the Poisson regression, associations with malnutrition remained for CHF FC and APMT (Table 5). BMI protected against malnutrition: Each increase in BMI of 1 kg/m^2 decreased risk for malnutrition by 2% ($P = 0.007$). A more severe FC of CHF substantially increased the risk for malnutrition; for example, risk for malnutrition is increased 44-fold among FC IV patients compared with FC I patients ($P < 0.001$). After controlling for FC of CHF, APMT remains as a protective factor against: Risk for malnutrition decreases 4% for every 1-mm increase in APMT (relative risk [RR], 0.959, $P < 0.001$).

Discussion

Most patients with CHF included in this study were male, >60 y of age, and overweight or obese. Recent studies have similarly shown an increase in the prevalence of CHF as the population ages and as average life expectancy increases, with men affected most strongly. One recent study reported that advanced age and obesity were associated with increased risk for cardiometabolic dysfunction and death in excessive CHF [18].

In the present study, use of the SGA revealed an increased prevalence of malnutrition (42.2%) among patients with severe CHF. Many of these undernourished patients presented with normal BMI, reinforcing the idea that BMI is not a good method for diagnosis of malnutrition [19]. Similar findings were reported by Gastelurrita et al., who used anthropometric measurements. Gastelurrita et al. found malnutrition in 44% of patients considered eutrophic and 14% of patients considered overweight or obese [20]. These results show the importance of hospital routines that include an evaluation sufficient to identify malnutrition in patients with CHF.

Several studies have reported a decrease in APMT in individuals with cancer [21] or AIDS [22], as well as in patients who are scheduled to undergo surgery [18–20] or hospitalized in the ICU [8].

Table 3
APMT values according to the nutritional status and sex in patients with CHF

Sex	Well-nourished mean ± SD	Malnourished mean ± SD	*P*-value*
Women	20.6 ± 3.8 mm	15.6 ± 3.6 mm	<0.001
Men	24.9 ± 4 mm	19.1 ± 4.1 mm	<0.001

APMT, Adductor pollicis muscle thickness; CHF, congestive heart failure.
*Non-paired *t* test.

Table 4
Factors associated to the nutritional status of patients with CHF (n = 500)

Characteristics	Well-nourished n (%)	Malnourished n (%)	*P*-value*
Sex			0.027
Women	130 (52.8)	116 (47.2)	
Men	159 (62.6)	95 (37.4)	
Age, y			<0.001
18–29.9	8 (53.3)	7 (46.7)	
30–59.9	85 (80.2)	21 (19.8)	
≥60	196 (51.7)	183 (48.3)	
Socioeconomic status†			0.028
A	19 (76)	6 (24)	
B	128 (63.4)	74 (36.6)	
C	122 (52.5)	111 (47.5)	
D/E	17 (53.1)	15 (46.9)	
BMI, kg/m^2			<0.001
<18.5	1 (6.3)	15 (93.7)	
18.5–24.9	92 (42.6)	124 (57.4)	
25–29.9	99 (68.3)	46 (31.7)	
≥30	97 (78.9)	26 (21.1)	
APMT			<0.001
≥P^5	283 (64.8)	154 (35.2)	
<P^5	6 (9.5)	57 (90.5)	
CHF functional class			<0.001‡
I	66 (98.5)	1 (1.5)	
II	140 (94)	9 (6)	
III	77 (61.6)	48 (38.4)	
IV	6 (3.8)	153 (96.2)	

BMI, body mass index; APMT, adductor pollicis muscle thickness; CHF, congestive heart failure.
*χ^2 test.
†Economic status according to Brazilian Association of Research Companies questionnaire, in which the levels A and B are considered high class, C is middle class, and D and E are low class.
‡Test for linear tendency.

Table 5
Multivariate analysis* of risk factors for malnutrition in 500 patients with CHF

Sex	RR	95% CI	*P*-value
BMI, kg/m^2	0.979	0.964–0.994	0.007
CHF functional class			
I	1		<0.001
II	3.753	0.496–28.367	
III	21.531	3.106–149.232	
IV	44.039	6.291–308.300	
APMT (mm)	0.959	0.942–0.977	<0.001

BMI, body mass index; APMT, adductor pollicis muscle thickness; CHF, congestive heart failure.
*Poisson regression adjusted to sex and age.

Several authors have reported a negative association between APMT and mortality in these patient populations [19]. However, few studies have evaluated APMT in patients with CHF. In the present study, 12.6% of patients with CHF presented APMT values below reference values for the healthy population [16]. The cross-sectional nature of this study prevented an investigation of the link between low APMT and mortality.

Almost 98% of well-nourished patients showed a normal APMT (P^5 or higher of the healthy population). This finding suggests that APMT could be a good screening test for malnutrition in these patients because of its high specificity (98%). APMT has a very low percentage of false positives: When the test is positive (low APMT) there is a great chance that it is a real positive case (malnourished patient).

Patients with CHF considered undernourished presented considerably lower APMT than those considered well nourished. This trend was true for both sexes. To our knowledge, few studies have investigated an association between APMT and nutritional status in patients with CHF. One study evaluated the relationship between APMT and SGA in older patients hospitalized in the ICU; the authors reported a meaningful association between decreased APMT and worse nutritional status in these patients [23]. However, the study used a non-validated instrument to evaluate APMT. Furthermore, the threshold used for both sexes (6.5 mm) was much lower than the P^5 recorded for values from a representative sample of this population (17.3 mm for men; 13 mm for women) [16].

In this study population of patients with CHF, increased risk for malnutrition was associated with factors such as sex, BMI, FC of CHF, and APMT values. The poor nutritional status associated with severe CHF likely derives from the increased catabolism, metabolic needs, and associated complications of this patient population [24].

APMT remained associated with increased risk for malnutrition, even after analysis controlling for other factors such as sex, age, BMI, and FC. Therefore, APMT may be considered a simple and low-cost marker for muscle mass, to be used as an objective tool for nutritional screening and patient management. Future longitudinal studies may prove its utility as a prognostic marker for mortality in patients with CHF.

The present study had some limitations. Although it only included patients seen at a single institution, the study population was a representative sample. The methodology used, including APMT thresholds, was appropriate for this patient population, but patients with edema should be excluded due to impairments of APMT measurements when fluid accumulation is present. APMT measurements are a simple and low-cost method for evaluation of muscle mass, in conjunction with nutritional status assessment.

Conclusion

Malnutrition is highly prevalent in patients with CHF. Risk is elevated among those who are male, those with low BMI, those with CHF FC III or IV, and those with low APMT values. APMT may be used as a simple index for muscle mass assessment and a screening test for malnutrition in these patients.

These findings demonstrate the importance of implementing hospital routines that prioritize nutritional evaluation in patients with CHF, as a measure for early identification of malnutrition. However, because few studies published to date have evaluated APMT in patients with CHF, longitudinal studies should be performed to confirm the prognostic value of this approach in clinical practice.

References

[1] Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010; 39:412–23.
[2] Htun NC, Ishikawa-Takata K, Kuroda A, Tanaka T, Kikutani T, Obuchi SP, et al. Screening for malnutrition in community dwelling older Japanese: preliminary development and evaluation of the Japanese Nutritional Risk Screening Tool (NRST). J Nutr Health Aging 2016;20:114–20.
[3] Delmonico MJ, Harris TB, Lee JS, Visser M, Nevitt M, Kritchevsky SB, et al. Alternative definitions of sarcopenia, lower extremity performance, and functional impairment with aging in older men and women. J Am Geriatr Soc 2007; 55:769–74.
[4] Murphy KT, Lynch GS. Update on emerging drugs for cancer cachexia. Expert Opin Emerg Drugs 2009;14:619–32.
[5] Von Haehling S, Steinbeck L, Doehner W, Springer J, Anker SD. Muscle wasting in heart failure: an overview. Int J Biochem Cell Biol 2013;45:2257–65.
[6] Von Haehling S, Ebner N, Dos Santos MR, Springer J, Anker SD. Muscle wasting and cachexia in heart failure: mechanisms and therapies. Nat Rev Cardiol 2017;14:323–41.
[7] Lameu EB, Gerude MF, Corrêa RC, Lima KA. Adductor pollicis muscle: a new anthropometric parameter. Rev Hosp Clin Fac Med Sao Paulo 2004;59:57–62.
[8] Ghorabi S, Ardehali H, Amiri Z, Vahdat Shariatpanahi Z. Association of the adductor pollicis muscle thickness with clinical outcomes in intensive care unit patients. Nutr Clin Pract 2016;31:523–6.
[9] Lew CCH, Ong F, Miller M. Validity of the adductor pollicis muscle as a component of nutritional screening in the hospital setting: a systematic review. Clin Nutr ESPEN 2016;16:1–7.
[10] Saitoh M, Rodrigues dos Santos M, von Haehling S. Muscle wasting in heart failure: the role of nutrition. Wien Klin Wochenschr 2016;128:455–65.
[11] Barbosa-Silva MCG, De Barros AJD. Subjective nutritional assessment: part 1 – review of its validity after two decades of use. Arch Gastroenterol 2002; 39:181–7.
[12] Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2000;894:i–xii.
[13] Brazilian Association of Research Companies. Brazil 2015 criteria and class distribution update 2016. Brazil Economic Classification Criterion 2016:1–6.
[14] Gonzalez MC, Borges LR, Silveira DH, Assunção MCF, Orlandi SP. Validation of a Portuguese version of patient-generated subjective global assessment. Rev Bras Nutr Clin 2010;25:102–8.
[15] Guedes ACB, Gama CR, Tiussi ACR. Nutritional assessment of the elderly, subjective global assessment (SGA) versus mini nutritional assessment (MAN®). Commun Science Health 2008;19:375–84.
[16] Bielemann RM, Horta BL, Orlandi SP, Barbosa-Silva TG, Gonzalez MC, Assunção MC, et al. Is adductor pollicis muscle thickness a good predictor of lean mass in adults? Clin Nutr 2016;35:1073–7.
[17] American Heart Association. Classes of heart failure. American Heart Association; 2013.
[18] European Society of Cardiology. 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS. Eur Heart J 2016;37:2893–962.
[19] Gonzalez MC, Correia MITD, Heymsfield SB. A requiem for BMI in the clinical setting. Curr Opin Clin Nutr Metab Care 2017;20:314–21.
[20] Gastelurrutia P, Lupón J, de Antonio M, Zamora E, Domingo M, Urrutia A, et al. Body mass index, body fat, and nutritional status of patients with heart failure: the PLICA study. Clin Nutr 2015;34:1233–8.
[21] Poziomyck AK, Corleta OC, Cavazzola LT, Weston AC, Lameu EB, Coelho LJ, et al. Adductor pollicis muscle thickness and prediction of postoperative mortality in patients with stomach cancer. Arq Bras Cir Dig 2018;31:1–4.
[22] Cortez AF, Tolentino JC, Elarrat RM, Freitas Passos RB. Association between adductor pollicis muscle thickness, anthropometric and immunological parameters in HIV-positive patients. Clin Nutr ESPEN 2017;17:105–9.
[23] Karst FP, Vieira RM, Barbiero S. Relationship between adductor pollicis muscle thickness and subjective global assessment in a cardiac intensive care unit. Rev Bras Ter Intensiva 2015;27:369–75.
[24] Gonçalves L, de B, Jesus NMT de, Gonçalvesz M, de B, Deiró TCB, de J, Dias LCG. Preoperative Nutritional status and clinical complications in the postoperative period of cardiac surgeries. Braz J Cardiovasc Surg 2016;31:371–80.