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Neck circumference and its association with anthropometric, clinical, and biochemical parameters in patients with chronic kidney disease on hemodialysis

Circunferência do pescoço e sua associação com parâmetros antropométricos, clínicos e bioquímicos em pacientes com doença renal crônica em hemodiálise

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ABSTRACT

Objective
To investigate the association between neck circumference and anthropometric, clinical, and biochemical parameters in chronic kidney failure patients on hemodialysis.

Methods
This is a cross-sectional study with patients with chronic kidney disease undergoing hemodialysis in Western Bahia. For the data collection, anthropometric measures were taken and clinical and biochemical data were gathered from the patient records and employing a structured questionnaire. A multiple linear regression was applied to evaluate the relationship between neck circumference and the anthropometric, clinical, and biochemical parameters.

Results
A total of 119 patients were evaluated, of which 63.03% were men and 57.98% were aged between 35 and 59 years old. The mean neck circumference of the patients was 36.2±3.8 cm. A negative association was found between neck circumference and the female sex (p<0.001), while waist circumference (p<0.001), the body adiposity index (p=0.002), and pre-dialysis serum urea concentration (p=0.006) were positively associated with neck circumference.

Conclusion
Neck circumference is inversely associated with the female sex and positively associated with a high waist circumference, body adiposity index, and serum urea concentration in patients with chronic kidney disease on hemodialysis.

Keywords: Anthropometry. Kidney diseases. Neck.

RESUMO

Objetivo

Investigar a associação entre circunferência do pescoço e parâmetros antropométricos, clínicos e bioquímicos em pacientes renais crônico sem hemodiálise.

Métodos

Trata-se de um estudo transversal com pacientes com doença renal crônica em hemodiálise no Oeste da Bahia. Para a coleta de dados foram aferidas medidas antropométricas e dados clínicos e bioquímicos foram coletados dos prontuários dos pacientes e por meio de um questionário estruturado. A análise de regressão linear múltipla foi aplicada para avaliar a relação entre a circunferência do pescoço e os parâmetros antropométricos, clínicos e bioquímicos.

Resultados

Foram avaliados 119 pacientes, sendo 63,03% homens e 57,98% com idade entre 35 e 59 anos. A média da circunferência do pescoço dos pacientes foi de 36,2±3,8 cm. Foi encontrada associação negativa entre a circunferência do pescoço e sexo feminino (p<0,001), enquanto a circunferência da cintura (p<0,001), o índice de adiposidade corporal (p=0,002) e a concentração sérica de ureia pré-diálise (p=0,006) foram positivamente associados à circunferência do pescoço.

Conclusão

A circunferência do pescoço está inversamente associada ao sexo feminino e positivamente associada a uma circunferência abdominal elevada, índice de adiposidade corporal e concentração sérica de ureia em pacientes com doença renal crônica em hemodiálise.

Palavras-chave: *Antropometria. Nefropatias. Pescoço.*

INTRODUCTION

Chronic Kidney Disease (CKD) is characterized by a kidney lesion and/or loss of kidney function for a period equal to or greater than three months. It is irreversible and, due to its evolution being slow and progressive, in many cases, the diagnosis is made late [1,2]. The treatments commonly used for CKD are transplants, drug combinations, and kidney replacement therapy. The latter may occur when the glomerular filtration rate is considerably low, often revealed by characteristic symptoms such as nausea, vomiting, drowsiness, and weight loss [1,3]. Roughly 13.4% of the global population have CKD, and in Brazil 11.0% of the population is estimated to have some degree of the disease [2,4].

The literature shows evidence of a relationship between Neck Circumference (NC) and the occurrence of or complications from some diseases. For example, Almeida et al. [5] identified a greater risk of cardiovascular disease in dialysis patients with a high NC, and Olatunji et al. [6] showed an independent association between NC and systemic arterial hypertension in young people and adults with sickle cell anemia. In a study with 107 participants conducted by Chu et al. [7] that evaluated risk factors for sleep apnea in patients undergoing hemodialysis, they found that a high NC is an independent factor for developing disordered breathing during sleep in dialysis patients.

Other cardiometabolic complications are observed in patients with a high NC, including obesity and the release of systemic fatty acids, which in turn is associated with insulin resistance and increased very-low density lipoprotein production [8,9]. A cross-sectional study conducted in China highlighted a negative association between an increase in NC and the glomerular filtration rate [10]. These data suggest that NC may be an important indicator contributing to the establishment and worse prognosis of CKD.

Although the predictive and outcome associations between a high NC and cardiovascular risk have been investigated in the current scientific literature, there is still a scarcity of studies in

Brazil that present the relationship of this anthropometric parameter in kidney failure patients. Thus, this study aims to verify the associations between neck circumference and sociodemographic, anthropometric, and clinical aspects in patients with CKD.

METHODS

This cross-sectional study was conducted between July of 2018 and November of 2019 with patients undergoing therapy in a hemodialysis center in a medium-sized Brazilian municipality, in the West of Bahia. The study did not include individuals under 18, pregnant women, patients who presented some limitations that prevented them from answering the research questionnaire, and those who refused to participate in the study.

The research was approved by the Human Research Ethics Committee, according to Resolution nº 466/2012 of the National Health Council of the Brazilian Ministry of Health (CAAE: 83803418.3.0000.8060, protocol nº 2.607.252), and all the participants signed the informed consent form, according to the principles of the Helsinki Declaration.

The data collection consisted of applying a structured questionnaire containing 55 questions with information related to the sociodemographic variables, such as sex, categorized as male or female; age, expressed in full years and categorized into age groups (<35, 35-59, ≥60); educational level, categorized as illiterate, elementary school/high school/vocational school, and higher education; and socioeconomic level, determined by the Brazilian Association of Research Companies and classified as high (A and B), intermediate (C), and low (D and E) [11].

The anthropometric and body composition data described below were collected after the hemodialysis session. The NC was measured with the help of a 1 mm precision inelastic tape measure (Sanny®, São Paulo, SP, Brazil), positioned above the cricoid cartilage and perpendicular to the long axis of the neck, with the participant in a seated position. In men with Adam's apple, the measure was taken below the prominence. To evaluate cardiovascular risk, values of ≥37 cm were used for men and ≥34 cm for women [12].

Dry body mass was determined with the help of electronic and cordless wheelchair scales, with a maximum capacity of 300 kg and 100 g sensitivity (SECA®, São Paulo, SP, Brazil); height was calculated using a fixed-rod compact stadiometer (WISO®, São Paulo, SP, Brazil). For those individuals unable to carry out this measurement, height was estimated using the full arm span. The Body Mass Index (BMI) was calculated based on the ratio between dry body mass in kilograms and height squared.

Waist Circumference (WC) was calculated between the mid-point of the last rib and the iliac crest [13]. Hip circumference was evaluated at the maximum extension of the gluteus region with the individuals standing upright with their thighs together. The Body Adiposity Index (BAI) was obtained using the formula: [hip circumference (cm) / height $(m)^{1.5}$] -18 [14].

Fat mass, lean mass and phase angle were obtained post-hemodialysis and determined with bioimpedance equipment (A-310, Biodynamics Corporation, Seattle, USA), positioning the patient horizontally and, using four plethysmographic electrodes, an unperceivable current detected the patient's lean mass and fat mass. Notably, the application of the structured questionnaire, the measurement of anthropometric data, and the analysis of body composition took place on the same day.

Based on the patients' medical records, information was obtained on hemodialysis time and serum concentrations of albumin, creatinine, and pre-dialysis urea.

The data analysis was carried out in Stata version 13.1 (Stata Corp, College Station, USA). Normality was evaluated by the Shapiro-Wilk test. The qualitative variables were described in relative frequency (%). The mean and standard deviation for the continuous variables were established. The Pearson's correlation test was used to investigate linear correlations between NC and the anthropometric, body composition, clinical, and biochemical variables. The associations between the independent variables and NC were determined using a multiple linear regression. All variables that met the selection criterion $p<0.20$ were included in the model using backward selection (age and socioeconomic level), and only those with $p\leq0.05$ remained in the model.

RESULTS

The hemodialysis unit had 156 registered patients, of which 140 were eligible for the survey. After analyzing discharges and deaths, the sample number of this study was 119 patients, of which the majority were of the male sex, reported they were married or had a partner, were aged between 35 and 59 years old, had attended elementary or high school, and had a low socioeconomic level (Table 1). It was observed that 14.3% of the patients had diabetes mellitus, and 69.7% had systemic arterial hypertension.

Table 1 – Sociodemographic characteristics of patients with chronic kidney disease on hemodialysis, in the West of Bahia. Bahia, Brazil, 2020.

Variables	N	%
Sex		
Male	75	63.03
Female	44	36.97
Age group (years)		
<34	27	22.69
35-59	69	57.98
>= 60	23	19.33
Educational level		
Illiterate	10	8.40
Elementary School / High School / Vocational school	104	87.40
Higher Education	5	4.20
Socioeconomic level		
High (A and B)	10	8.40
Intermediate (C)	50	42.01
Low (D and E)	59	49.59

The following measurements were observed: 52.3% of women and 61.3% of men had neck circumference above the appropriate, indicating cardiovascular risk, a mean of 36.2±3.8 cm for neck circumference, 24.1±5.1 Kg/m^2 for the body mass index and 87.5±13.0 cm for waist circumference. The mean value of the body adiposity index of the patients on hemodialysis was 76.4±2, 17.2±9.0 Kg for fat mass, 49.2±11.7 kg for the lean mass, and 6.9±1.9° for the phase angle. The hemodialysis time was estimated in months, and a mean time of 27.1±38.1 months of therapy was observed. The mean serum values were 3.5±0.5 g/dL for albumin, 8.6±3.6 mg/dL for creatinine, and 156.8±47.9 mg/dL for pre-dialysis urea.

In the correlation analysis (Table 2), a positive correlation was observed between NC and BMI (p<0.001), WC (p<0.001), BAI (p<0.001), fat mass (p=0.016), lean mass (p<0.001), phase angle (p=0.027) and serum creatinine concentration (p=0.001), but the r values indicate a weak correlation.

Table 3 presents the neck circumference determinants through single and multiple analyses in linear regression. After adjusting the variables among themselves, a negative association was found between NC and the female sex (p<0.001), while WC (p<0.001), BAI (p=0.002), and pre-dialysis serum urea concentration (p=0.006) were positively associated with NC.

Table 2 – Correlation between neck circumference and anthropometric, body composition, clinical, and biochemical variables in patients with chronic kidney disease on hemodialysis, in the West of Bahia. Bahia, Brazil, 2020.

Variables	Neck circumference		
	Women	Male	General
	r (*p*-value)	*r* (*p*-value)	*r* (*p*-value)
Body mass index (Kg/m^2)	0.609 (<0.001)	0.656 (<0.001)	0.454 (<0.001)
Waist circumference (cm)	0.652 (<0.001)	0.599 (<0.001)	0.488 (<0.001)
Body adiposity index	0.529 (<0.001)	0.620 (<0.001)	0.421 (<0.001)
Fat mass (Kg)	0.465 (0.001)	0.489 (<0.001)	0.221 (0.016)
Lean mass (Kg)	0.563 (<0.001)	0.516 (<0.001)	0.634 (<0.001)
Phase angle (°)	0.224 (0.142)	0.103 (0.382)	0.204 (0.027)
Time on hemodialysis (months)	-0.051 (0.745)	-0.073 (0.544)	-0.137 (0.147)
Serum albumin concentration (g/dL)	-0.115 (0.465)	-0.210 (0.008)	-0.091 (0.347)
Serum creatinine concentration (mg/dL)	-0.016 (0.929)	0.248 (0.075)	0.340 (0.001)
Pre-dialysis serum urea concentration (mg/dL)	-0.033 (0.834)	0.199 (0.107)	0.142 (0.141)

Table 3 – Simple and multiple linear regression coefficients, confidence intervals, and p-value for the neck perimeter of patients with chronic kidney disease on hemodialysis, in the West of Bahia. Bahia, Brazil, 2020.

Variables	Simple linear model			Multiple linear model		
	ß	95% CI	*p*	ßAj	95% CI	*p*
Sex	-3.715	-4.981; -2.449	<0.001	-4.116	-5.140; -3.02	<0.001
Age group	0.771	-0.290; 1.833	0.153			
Educational level	-0.967	-2.926; 0.992	0.330			
Socioeconomic level	-0.381	-1.487; 0.724	0.496			
Body mass index (Kg/m^2)	0.333	0.212; 0.454	<0.001			
Waist circumference (cm)	0.136	0.0914; 0.180	<0.001	0.957	0.041; 0.149	<0.001
Body adiposity index	0.170	0.103; 0.238	<0.001	0.116	0.042; 0.189	0.002
Fat mass (Kg)	0.207	0.160; 0.254	<0.001			
Lean mass (Kg)	0.207	0.160; 0.254	<0.001			
Phase angle (°)	0.393	0.044; 0.742	0.027			
Time on hemodialysis (months)	-0.013	-0.031; 0.004	0.148			
Serum albumin concentration (g/dL)	-0.681	-2.111; 0.749	0.347			
Serum creatinine concentration (mg/dL)	0.434	0.168; 0.700	0.002			
Pre-dialysis serum urea concentration (mg/dL)	0.011	-0.004; 0.027	0.142	0.015	0.004; 0.025	0.006

Note: Data are adjusted for age and socioeconomic level. CI: Confidence Interval; ß: ß value for the simple linear regression; ßAj: Adjusted ß value; *p*-value: multiple linear regression adopting significance for p<0.05. Significant values are in bold.

DISCUSSION

In this study, we sought to verify the association between NC and sociodemographic, anthropometric, body composition, clinical, and biochemical aspects in patients with CKD. As the main results, we found a negative association between NC and the female sex, as well as a positive association between NC and WC, between NC and BAI, and between NC and pre-dialysis serum urea concentration.

The NC has been shown to be a reliable anthropometric measure of subcutaneous adiposity of the upper body. The positive association found between it and WC and between it and the BAI enables us to infer that a simple, easy-to-obtain measure with little possibility of measurement error is of major importance to clinical practice in patients with CKD, since there is evidence that obesity is an important risk factor for kidney failure [15,16].

Our study population presented a mean neck circumference of 36.23±3.80 cm, a lower value than that found by Hsiao et al. [17], which was 38.7±3.8 cm. When we evaluated this measure according to sex, we verified that the mean length was 33.89±2.98 cm and 37.61±3.56 cm among men and women, respectively, which shows the need to evaluate the measure by sex and not only in general.

The negative association between NC and being of the female sex found in this study corroborates other publications [18,19]. In the study of Yoon et al. [20], the women had a lower NC when compared with the present study; however, this anthropometric parameter was considered to be an independent predictor in the development of CKD in the female sex, an affirmation attributed to the differences in lipid metabolism and the influence of adipose tissues in the different sexes.

It warrants mentioning that a study conducted by Xue et al. [10] with a large sample of the Chinese population showed that a high NC was significantly associated with a greater risk of a reduction in the glomerular filtration rate, and it was independently associated with the risk of a reduced glomerular filtration rate in the Chinese population. This enables us to infer that NC can contribute to evaluating the risk of kidney failure.

A predominance of patients of the male sex with CKD has already been described in other studies, such as that of Santiago et al. [21], in which a total of 72.5% of the population investigated was composed of men, and that of Hsiao et al. [17], in which 70.6% of those investigated were of the male sex. A low socioeconomic level was also previously described in the study of Santiago et al. [21], where 72.5% of the participants belonged to classes D and E. Faleiro et al. [22] draw attention to the occurrence of a high prevalence of individuals from a low social class in the results of the research and that this may be influenced by the location where it is conducted. In our study, there is a predominance of patients who are treated by the *Sistema* Único *de Saúde* (Unified Health System) among those evaluated and thus, who probably have a lower socioeconomic level than individuals who undergo their treatment in private clinics.

Regarding NC, this has been recognized as a parameter indicating cardiometabolic diseases [23], which has been promising in evaluating the risk of kidney failure [10]. Medeiros et al. [24] showed that NC is associated with cardiometabolic risk factors in kidney failure patients on hemodialysis on a transplant waiting list, and Liu et al. [25] found an association between NC and CKD indicators for patients at high cardiometabolic risk. In addition, the study of Hsiao et al. [17] showed evidence that NC and albuminuria are determining factors for a precise and successful estimate of the glomerular filtration rate in patients at high cardiovascular risk, suggesting that NC should potentially be investigated in more studies.

The present study showed a positive association between NC and the central obesity marker (WC) in adults with CKD on hemodialysis, after adjustments. The study of Ang et al. [26] reported a strong general correlation between NC and WC in individuals from the Philippines, as well as with the components of metabolic syndrome and, therefore, with the risk of cardiovascular disease. Neck circumference has been considered an important marker of subcutaneous fat deposits in the upper body and a simple screening tool for identifying individuals with obesity [27,28]. In this sense, increased values suggest a greater risk for cardiovascular diseases in the population in general and in

kidney failure patients [9,24]. The fatty acids released from subcutaneous fat in the upper body can result in oxidative stress and vascular lesions, causing an increased risk for cardiovascular diseases in individuals with higher NC [9,29].

In our study, we observed that NC was associated with excess body fat, estimated by the BAI. The results of a systematic review show that NC is directly associated with adiposity markers in adults. In addition, NC is consistently associated in all the studies with total and central adiposity markers such as BMI, waist circumference, and waist-hip ratio in the adult population [30]. The BAI was proposed by Bergman et al. [31] as a simple alternative for predicting body fat, due to the methods employed requiring the use of equipment or presenting limitations for predicting body adiposity [32,33]. Despite this index presenting validity, no studies in kidney failure patients were identified, limiting the comparison of these results [32,34].

We identified that NC and pre-dialysis serum urea concentrations were positively associated. For an increase of 1 cm in the anthropometric measurement, there is an increase of 0.015 mg/dL in the aforementioned biochemical test. In the present study, it is impossible to identify why urea was negatively associated with neck circumference. Therefore, it is suggested that further studies seek to elucidate this relationship.

Some limitations of the study should be considered, such as the reduced sample size due to the presence of a hemodialysis catheter in the neck of some patients preventing the NC measurement, and the biochemical doses being carried out infrequently at the health unit. In addition, due to the present study's cross-sectional nature, it is impossible to establish the directionality of the associations, and the possibility of reverse causality cannot be excluded. A strong point of the present study includes its originality, as few studies have investigated the relationship between neck circumference and sociodemographic, anthropometric, body composition, clinical, and biochemical parameters in CKD patients on dialysis.

CONCLUSION

In conclusion, a high neck circumference is negatively associated with the female sex and positively associated with increased waist circumference, body adiposity, and serum urea concentrations. Future studies should investigate the relationship between a high neck circumference and morbidity and mortality in patients with CKD.

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CONTRIBUTORS

DCG SILVA, AMS ALVES, TC SANTOS, and JNM ALMEIRA contributed to the conception and design of the study, data collection and data analysis and interpretation. They wrote the article, revised and approved the final version of the article. FG FERREIRA contributed to the analysis and interpretation of data. He wrote the article, revised and approved the final version of the article.