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Original Article

Serum nutritional indexes and body composition parameters evaluated by body impedance analysis: differences between patients with acute myocardial infarction and stable coronary artery disease

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Abstract: Objective: We assessed the association between serum nutritional status indexes and body composition evaluated by body impedance analysis (BIA) in Chinese subjects with coronary artery disease (CAD). Furthermore, we determined if there were differences in any of these parameters between patients with acute myocardial infarction (AMI) and stable CAD. Methods: The study included 48 CAD patients (15 with AMI and 33 with stable CAD). Body mass index, body weight, percent body fat and percent skeletal muscle were measured during hospitalization by BIA. Main blood lipid levels and serum albumin, prealbumin and total lymphocyte count (TLC) were determined by standard biochemical methods. Pearson's correlation coefficients were determined to assess the relationships between the body composition parameters and serum albumin, prealbumin and TLC. Results: Compared to patients with stable CAD, those with AMI had higher serum levels of triglycerides and LDL-C and a higher ratio of dyslipidemia (all P<0.05). Furthermore, compared to patients with stable CAD, TLC and main body composition parameters were higher in the AMI group (all *P*<0.05). TLC was significantly correlated with most body composition parameters (all *P*<0.05), whereas serum albumin and prealbumin levels were similar between the two groups and not significantly correlated with these body composition parameters (all *P*>0.05). Conclusion: Our findings show that TLC and the body composition parameters evaluated by BIA were significantly different between small sample patients with AMI and stable CAD. Furthermore, TLC was significantly correlated the body composition parameters, which might be useful for clinical risk assessment.

Keywords: Stable coronary artery disease, acute myocardial infarction, body composition, association, nutrition status, risk assessment

Introduction

The prevalence of cardiovascular disease (CVD) has been continuously increasing in China, and coronary artery disease (CAD) is one of the main causes of death in the Chinese population [1]. It is estimated that the number of patients with CVD in China is 290 million, and that 2.5 million have a history of myocardial infarction. Furthermore, the total economic burden of ischemic heart disease was $10.31 million in 2008 [2].

Fortunately, in addition to thrombolysis, percutaneous coronary intervention (PCI) and coronary artery bypass grafting, there has been recent progress in the treatment of CAD with evidence-proven medications including aspirin, β-blockers, statins, and angiotensin converting enzyme inhibitors or angiotensin receptor blockers [3-6].

Furthermore, the development of new alternative-based approaches for cardiac rehabilitation such as nutrition status assessment and nutrition modification plus exercise are of great importance for CAD risk assessment and secondary prevention [7-10].

Traditionally, nutrition status assessment has been evaluated by biochemical markers such as serum albumin, prealbumin and total lym-

phocyte count (TLC) [11]. More recently, bioelectrical impedance analysis (BIA) has been recognized as a noninvasive method for indirect estimation of body composition [12, 13]. Furthermore, it has proven reliable as a reflection of body composition and patients' nutritional status [9, 14-16].

Despite advances in impedance analysis to determine body composition, the available data are still limited. In particular, there is a lack of data on the association between the impedance parameters and indexes of nutritional status in patients with stable CAD or in critically unstable patients such as those with acute myocardial infarction (AMI). Furthermore, it is not clear how to make the best use of these parameters to improve risk assessment in those subjects with moderate or high risk. Therefore, this study was performed to determine the relationships between body composition parameters evaluated with BIA and main serum nutritional status indexes in patients with CAD.

Methods

Study subjects

From March 2015 to September 2015, 48 patients diagnosed with CAD were recruited from the Department of Cardiology of Shanghai Jiao Tong University 6th People's Hospital, East Campus, China. There were 15 patients with AMI and 33 patients with stable CAD. CAD was defined as coronary stenosis (≥70%) in at least one of the three main coronary arteries or their major branches, as assessed by coronary angiography (CAG) or a history of myocardial infarction defined according to World Health Organization criteria. The diagnosis of stable CAD and AMI were defined according to available guidelines [17, 18]. Patients who met any of the following criteria were excluded: acute inflammation, type 1 diabetes, congenital heart disease, a contraindication for the use of contrast media due to severe liver or kidney disease, a BMI>30 kg/m^2 or <18 kg/m^2, or skin damage on the area where the electrodes for BIA were attached. The Medical Ethics Committee of Shanghai Jiao Tong University Sixth People's Hospital East Campus approved this study. Each patient gave written informed consent before the study began.

Coronary angiography and clinical therapy

All participants underwent elective CAG during hospitalization. The degree of coronary stenosis in the main vessels and/or side branches was judged by two cardiologists who were blinded to the study protocol. The use of medications and interventional strategies for clinical therapy were at the discretion of the physicians and based on current guidelines.

Clinical parameters and the determination of risk factors

Clinical data including height, weight, age, gender, and traditional risk factors such as hypertension, type 2 diabetes mellitus (T2DM), smoking, and dyslipidemia were collected for analysis. Serum albumin, prealbumin, TLC, hemoglobin, creatinine, cystatin C, and the concentrations of fasting blood sugar (FBS), total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) were determined by standard biochemical methods using an automated chemistry analyzer (Synchron Clinical System LX20; Beckman Coulter, Brea, CA, USA). The methods used to define smoking status and the presence of hypertension and T2DM have been previously described [19, 20].

BIA data determination and collection

The Inbody 720 (Biospace, Seoul, South Korea) was used to obtain the main BIA parameters. BIA device has been validated for the Chinese population. Patients were in the standing position on the platform of the machine during all measurements. The BIA measurements were performed according to the manufacturer's instructions. The main BIA data gathered in the present study included basal metabolic rate (BMR), skeletal muscle mass (SMM), lean body mass (LBM), percent of body fat (PBF), fat mass (FM), waist-hip ratio (WHR), muscle mass (MM) and visceral fat area (VFA). All measurements with the Inbody 720 were performed by special staff after training.

Statistical analyses

Statistical analysis was performed using SPSS 19.0 for Windows (SPSS, Inc., Chicago, IL, USA). Normally distributed data were expressed as the mean ± SD, and groups were compared

Table 1. Summary of baseline characteristics in patients with AMI and stable CAD

	AMI (n=15)	Stable CAD (n=33)	*P* values
Age, years	65.80±11.00	65.36±9.23	0.802
Total lymphocyte count, $\times 10^9$/L	1.74±0.76	1.57±0.68	0.032
Albumin, g/L	40.00±3.23	40.80±4.77	0.573
Hemoglobin, g/L	136.6±11.5	131.3±16.7	0.268
Prealbumin, mg/L	220.16±32.5	236.9±40.7	0.324
Creatinine, μmol/L	69.86±13.56	77.28±36.81	0.456
Cystatin C, mg/L	0.85±0.16	0.93±0.25	0.507
Fasting blood sugar, mmol/L	7.87±3.39	5.98±1.38	0.110
Total cholesterol, mmol/L	4.89±1.10	4.20±1.11	0.066
Triglyceride, mmol/L	2.15±1.50	1.41±0.77	0.031
Low-density lipoprotein cholesterol, mmol/L	3.50±0.85	2.80±0.99	0.027
High-density lipoprotein cholesterol, mmol/L	1.03±0.18	1.17±0.45	0.292
Height, cm	167.4±8.1	166.8±7.9	0.382
Weight, kg	69.24±4.87	69.79±5.28	0.867
Body mass index, kg/m^2	24.86±2.2	25.11±2.9	0.870
Male, n (%)	11 (73.3)	20 (60.6)	0.393
Smoking, n (%)	10 (66.7)	14 (42.4)	0.119
Hypertension, n (%)	6 (40.0)	22 (66.7)	0.082
T2DM, n (%)	5 (33.3)	9 (27.3)	0.669
Dyslipidemia, n (%)	9 (60.0)	7 (21.2)	0.008

Data are expressed as the number of individuals (percentage in parentheses) or the mean ± SD, as appropriate. AMI, acute myocardial infarction; CAD, coronary artery disease; T2DM, type 2 diabetes mellitus.

using a Student's unpaired t-test. The significance of intergroup differences for categorical variables was determined using a chi-square test. Two-tailed *P* values <0.05 were considered significant. Pearson's correlation coefficient (r) was calculated to determine relationships between serum albumin, prealbumin, TLC, BMI and the main BIA data, which included BMR, SMM, LBM, PBF, FM, WHR, MM and VFA.

Results

*Comparison of baseline characteristics between patients with AMI and stable CAD (**Table 1**)*

A total of 48 patients with CAD were enrolled, including 15 with AMI and 33 with stable CAD. **Table 1** summarizes the baseline characteristics of the 48 study subjects. Compared to patients with stable CAD, the group with AMI had higher values of TLC, triglycerides and LDL-C (all P<0.05). Furthermore, the group with AMI had a higher ratio of dyslipidemia (P<0.05).

In spite of the differences noted above, patients with AMI had similar average height, weight, BMI, serum albumin, prealbumin, hemoglobin, creatinine, cystatin C, and concentrations of FBS, TC and HDL-C (all P>0.05). Furthermore, the two groups had similar ratios of smoking, hypertension and T2DM (all P>0.05) (**Table 1**).

*Comparison of the main BIA parameters between patients with AMI and stable CAD (**Table 2**)*

The main BIA data gathered in the present study included BMR, SMM, LBM, PBF, FM, WHR, MM and VFA. Compared to patients with stable CAD, patients with AMI had higher values of BMR, SMM, LBM, FM, WHR, MM and VFA (all P<0.05). However, the PBF was similar between the two groups (P>0.05) (**Table 2**).

*Analysis of correlations between nutrition status indexes and selected BIA parameters (**Table 3**)*

Table 3 shows the strength of the correlations between the various nutritional status indexes (serum albumin, prealbumin, TLC and BMI) and the selected main BIA variables (BMR, SMM, LBM, PBF, FM, WHR, MM and VFA). Positive cor-

Table 2. Summary of the main BIA parameters in patients with AMI and stable CAD

	AMI (n=15)	Stable CAD (n=33)	*P* values
Basal metabolic rate, kcal	1500.60±228.42	1368.90±192.78	0.044
Skeletal muscle mass, kg	29.05±6.34	25.20±5.31	0.034
Fat mass, kg	25.66±6.93	19.98±5.04	0.002
Percent of body fat, %	32.81±5.82	30.24±6.84	0.213
Waist-hip ratio	0.98±0.04	0.92±0.06	0.001
Muscle mass, kg	49.42±9.99	43.65±8.48	0.044
Lean body mass, kg	52.34±10.57	46.25±8.92	0.044
Visceral fat area, cm^2	124.84±37.13	100.31±32.25	0.024

Data are expressed as the mean ± SD. AMI, acute myocardial infarction; CAD, coronary artery disease.

Table 3. Summary of bivariate correlation analysis

	Nutritional status assessment					
	Serum albumin		Prealbumin		Total lymphocyte count	
	r	p	r	P	r	P
Basal metabolic rate, kcal	-0.053	0.734	0.162	0.565	0.341	0.018
Height, cm	0.085	0.583	0.200	0.475	0.260	0.074
Weight, kg	-0.055	0.722	0.164	0.560	0.453	0.001
Skeletal muscle mass kg	-0.051	0.743	0.171	0.543	0.350	0.015
Fat mass, kg	-0.030	0.849	0.102	0.717	0.394	0.006
Percent of body fat, %	0.056	0.720	-0.045	0.874	0.201	0.171
Waist-hip ratio	-0.121	0.436	0.194	0.488	0.292	0.044
Body mass index, kg/m^2	-0.158	0.307	0.099	0.727	0.458	0.001
Muscle mass, kg	-0.054	0.727	0.163	0.561	0.339	0.019
Lean body mass, kg	-0.052	0.737	0.162	0.565	0.341	0.018
Visceral fat area, cm^2	-0.055	0.725	0.021	0.942	0.301	0.037

relations in the study population were found between TLC and BMR, weight, SMM, FM, WHR, BMI, MM, LBM and VFA (all $P<0.05$). Pearson's correlation analysis did not show any significant associations between serum albumin or prealbumin and the above-mentioned main BIA parameters (all $P>0.05$). Furthermore, there were no significant associations between TLC and height or PBF (all $P>0.05$) (**Table 3**).

Discussion

This is the first study to explore the clinical relevance of nutritional status indexes and the body composition parameters evaluated by BIA in Chinese patients with AMI and stable CAD. We found that there were important differences in the TLC and main body composition parameters evaluated by BIA between patients with AMI and stable CAD. Furthermore, TLC and the main body composition parameters were significantly correlated.

Nutritional status assessed by biochemical indicators and BIA have been proven to be reliable estimates of body composition [11-13]. This underscores the importance of using these noninvasive methods as tools for nonpharmacological interventions or strategies aimed at early risk detection and assessment. It is well known that BMI is a risk factor for CVD, but other factors such as WHR (central obesity) may have more prognostic value [20, 21]. However, there is little information on the prognostic value of many of BIA parameters and TLC, and further research is required to clarify their prognostic value.

In the current study, we collected nutrition status indexes and body composition parameters by BIA after the acute stage of AMI to avoid the influence of acute stress on these indicators. We found that patients with AMI had a higher value of TLC and a higher ratio of dyslipidemia than patients with stable CAD. However, patients in the two groups had similar average height, weight, BMI, serum albumin, prealbumin and similar ratios of smoking, hypertension and T2DM. It is well known that central obesity can be defined by WHR values; however, in this study, we did not divide the patients into subgroups of males and females because of the relatively small sample size.

By using BIA, we were able to acquire data in CAD patients on their nutritional status, which might be useful in risk assessment and secondary prevention. The main BIA parameters analyzed in the present study included BMR, SMM, LBM, PBF, FM, WHR, MM and VFA. Compared to patients with stable CAD, patients with AMI had higher values of BMR, SMM, LBM,

FM, WHR, MM and VFA. However, the PBF was similar between the two groups. Furthermore, correlation analysis revealed that there were positive correlations between TLC and BMR, weight, SMM, FM, WHR, BMI, MM, LBM and VFA. However, Pearson's correlation analysis did not show any significant associations between serum albumin, prealbumin and the above-mentioned BIA parameters. Furthermore, there were no significant associations between TLC and height and PBF. The reasons for the inconsistent association between some of the nutritional indeses and the main BIA parameters might have been due to the characteristics of the study population. In our study, only patients with stable CAD and AMI were enrolled, and this is different from other studies that enrolled patients who were malnourished or critically ill [15]. Previous studies have shown that even compared with dual energy X-ray absorptiometry, nutritional status assessment using BIA is a valid measurement tool in Chinese and European adults [9, 10].

Patients with AMI are clinically unstable and require immediate treatment. In this study, PCI was used more frequently in the AMI group than in the stable CAD group, and this was in accordance with current guidelines. Furthermore, the use of noninvasive strategies to assess risk should be further implemented as a means of preventing AMI. Long-term CAD risk might be reduced by the use of measures that modify TLC and the BIA parameters, in combination with education, life-style modification, drug therapy and an increase in primary care visits [21-23].

The current study has both strengths and limitations. First, the study sample size was small, and all subjects were enrolled from one tertiary hospital. Since the subjects did not reflect the general population, the results cannot be extrapolated directly to other populations. A strength of our study is that all subjects underwent CAG and met the critical diagnostic criteria for stable CAD or AMI. Furthermore, all BIA parameters were collected by experienced researchers, and this increases the validity of our study results. Since patients with AMI belong to a very high-risk group that has a poor mid- and long-term prognosis, our results should be helpful to physicians in real world practice. An additonal limitaiton of the present study is the lack of long-term follow-up to assess the relationship between future events or disease progression and the TLC and BIA parameters.

Conclusions

We evaluated nutritional status indexes and body composition parameters by BIA in a small sample Chinese subjects with CAD. Our findings show, for the first time, that there are differences in the TLC and main body composition parameters between AMI and stable CAD patients. Furthermore, TLC was significantly correlated with the main body composition parameters. Further studies are needed to confirm this association and more effective measures should be taken to modify available risk factors in patients with stable CAD before the occurrence of AMI.

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Disclosure of conflict of interest

None.

Authors' contribution

Z C and WG S conceived and designed the study, interpreted the results, finished the data analysis and wrote the manuscript. FY X, QK Z and YH T participated in the laboratory tests and data collection. L W, XD W and YW G helped interpret the results. All authors read and approved the final manuscript.

Abbreviations

AMI, acute myocardial infarction; BIA, body impedance analysis; BMI, body mass index; BMR, basal metabolic rate; CAD, coronary artery disease; CAG, coronary angiography; CVD, cardiovascular disease; FBS, fasting blood sugar; FM, fat mass; HDL-C, high-density lipoprotein cho-

lesterol; LBM, lean body mass; LDL-C, low-density lipoprotein cholesterol; MM, muscle mass; PBF, percent of body fat; PCI, percutaneous coronary intervention; SMM, skeletal muscle mass; TC, total cholesterol; T2DM, type 2 diabetes mellitus; TG, triglyceride; TLC, total lymphocyte count; VFA, visceral fat area; WHR, waist-hip ratio.

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