Applied nutritional investigation

Bioelectrical impedance vector analysis, phase-angle assessment and relationship with malnutrition risk in a cohort of frail older hospital patients in the United Kingdom

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ABSTRACT

Objective: Bioelectrical impedance vector analysis (BIVA) and phase angle (PA) have been shown previously to indicate relative nutritional status in patients. The aim of this study was to investigate the application of BIVA and PA assessments in a cohort of frail older hospital patients and compare these assessments with malnutrition risk screening by MUST (Malnutrition Universal Screening Tool), and the MNA-SF® (Mini-Nutritional Assessment-Short Form).
Methods: Sixty-nine patients (n = 44 men; n = 25 women; age 82.1 ± 7.6 y [range 62–96 y]; body mass index 25.8 ± 5.4 kg/m² [range 16.6–45.1 kg/m²]) were recruited from hospital wards specializing in the care of frail older individuals from the United Kingdom. Bioelectrical impedance assessment was performed at 50 khz frequency, BIVA was performed using raw impedance data, PA was calculated, and data were compared against reference population groups. Patients were categorized by malnutrition risk by MUST and MNA-SF.
Results: BIVA indicated that the men and women in the study were significantly different from reference population groups ($P < 0.0001$), with a noticeable reduced capacitive reactance (xC) component. The group mean PA was 4.6° ± 1.1° (2.4°–9.2°). The mean PA for men was 4.7° ± 1.3° (2.4°–9.2°), and for women it was 4.5° ± 0.7° (2.8–6.0°). Group PA correlated with MNA-SF score ($P = 0.05$). MUST categorized patients predominantly at low risk for malnutrition (80%); whereas MNA-SF was at risk (46%) and malnourished (45%).
Conclusions: The significant reduction in xC component and PA is consistent with other studies and is indicative of a reduced body cell mass and nutritional status with aging and illness. The general trend in MNA-SF scoring was more consistent with these patterns as a group; but requires clarification in larger cohorts. Future studies are necessary with an aim to improve and optimize care of frail older people.

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Introduction

Aging and frailty are associated with physiological and potentially pathological changes that may increase the risk for malnutrition, including a reduction in appetite and food intake, a decrease in body protein, body cell mass (BCM), and skeletal muscle mass

(SMM) [1–4]. The frailty phenotype may increase risk for morbidity and mortality, and frail older people may suffer from a range of acute and chronic illness, and present with sarcopenic, cachectic, and wasting conditions [1,4–6]. Hence, the ability to accurately determine nutritional status in older people in hospitals and long-term care (LTC) facilities has high clinical importance and specific nutritional risk-screening tools have been developed and endorsed [7]. Currently in the United Kingdom, the MUST (Malnutrition Universal Screening Tool) is the gold standard used routinely in hospitals and LTC facilities in the screening of malnutrition and is endorsed by the British Association of Parenteral and Enteral Nutrition [7,8]. The MNA (Mini-Nutritional Assessment) also has been validated for use in older populations [7,9–11].

Bioelectrical impedance assessment (BIA) is an established, noninvasive portable tool for assessing body composition, and has potential use in assessing nutritional and clinical status [12–14]. One issue of concern, however, is that BIA predictive equations may cause significant errors in older people and in comorbid states (e.g., due to potential hydration abnormalities, body measurement differences, and other unknown effects); thus use of raw impedance data, that is, the bioelectrical impedance vector analysis (BIVA) method by Piccoli and Pastori has been suggested [12–16]. The methodology is based on the concept that body impedance (Z) is made up of two components—resistance (R) and reactance capacitance (xC)—and that by normalizing R and xC for height (H) in meters, and plotting relevant bivariate vectors in a graphical format, useful comparisons can be made (e.g., compared with reference populations with specified ages, sex, body mass index [BMI] and disease) [15,16]. The R component relates predominantly to water content and hydrated tissues and, in the normal healthy state, a decreased R/H correlates with body size (i.e., greater amount of hydrated tissue mass), and in illness may relate to edema and high water content. Similarly, a very high R in illness may relate to dehydration and wasting. The xC component relates to the electrical capacitance or reactance effects of cellular tissues (i.e., cell membrane, etc). Therefore, a high xC relates to higher BCM/lean mass and a low xC relates to lower BCM/lean mass. A lowering of xC is consistent with normal aging. More recently, a specific BIVA method was developed with demonstrated accuracy by using body circumference measurements [17].

The BIA phase angle (PA) reflects the contributions between R and xC [calculated using the equation: $PA \, (degrees) = \arctan (Xc/R) \times (180/\pi)$]. It has been found to be associated with nutritional status and to have prognostic potential in different disease states and in older patients [14,18–20]. The usefulness of the clinical application of the BIVA and PA measurements in frail older people is yet to be realized and is at present unknown. Furthermore, at present there have been only a handful of studies performed globally and from the United Kingdom assessing the relationship between BIVA and PA in frail older people and the relationship with risk for malnutrition.

Therefore, the aims of this study were to investigate the use of BIVA and PA in frail older hospital inpatients and compare the relationship to malnutrition screening by MUST and MNA-SF.

Methods

Participants and study design

This cohort study was undertaken between September 2012 and May 2013. Patients who were able to provide written informed consent were recruited consecutively from admissions to two hospital wards in Lincoln, United Kingdom, specializing in care of frail older patients. Patients were diagnosed as being significantly frail and with a range of comorbities that included cardiovascular disease, chronic heart failure, chronic kidney disease, chronic obstructive pulmonary disorder, cancer, diabetes, arthritis, and dementia. Patients were treated with polypharmacy. Full ethical approval was obtained from NHS Leicester, East Midlands Research Ethics Committee before study commencement. Ethical guidelines were followed and informed consent sought from all patients. Exclusion criteria from the study were inability or unwillingness to give informed consent, patients nil by mouth or were tube fed. BIA measures were contraindicated in patients with defibrillation or cardiac pacemaker devices. The aim was to recruit 100 to 150 patients in line with other similar studies; however the exclusion criterion of

ability to consent and designated study time restraints dictated the current number.

Anthropometric measurements

Height (m) and weight (kg) measurements were completed by clinical staff. In some cases height had to be estimated (e.g., height from demi-span). BMI was calculated in kg/m^2.

Bioelectrical impedance measurements

BIA measurements were taken using a single-frequency (50 kHz) Maltron® 916 S, bioelectrical impedance analyzer (Maltron International Ltd., Rayleigh, Essex, UK). Measurements were taken using a standard hand-to-foot tetra-polar technique with participants in the supine position, in accordance with the manufacturer's guidelines. Raw impedance measurements of resistance, R and capacitance, xC in ohms and PA were recorded. The PA component was calculated using the equation: $PA \, (degrees) = \arctan (Xc/R) \times (180/\pi)$. R and xC data was used for subsequent BIVA analysis according to previous studies [15,16]. Participants' R and xC were normalized for H and group mean data $\pm$SD were calculated. Data for the male and female groups were inputted into BIVA software and compared with the reference healthy adult population using confidence ellipses. Additionally, BIVA was performed on different MNA-SF and MUST screening categories for men and women.

Nutritional assessment: MUST tool and MNA-SF screening

MUST and MNA-SF screening were undertaken by clinical staff according to instructions and scores recorded. Scores were converted into categories for nutritional status using MUST and MNA scoring criteria either low risk/normal (0 points MUST; 12–14 MNA-SF), medium risk/at risk (1 point MUST; 8–11 MNA-SF) and high risk/malnourished ($\geq$2 points MUST; 0–7 MNA-SF).

Data analysis

Data is presented as mean average measurements $\pm$ SD with a range (minimum–maximum) and (median) values. Data were grouped into whole-participant group, women and men, and where relevant into BMI and nutritional screening categories. Statistical analysis was performed using IBM SPSS Statistics, version 19 (New York, NY USA). *t* Tests, analysis of variance, and Pearson correlations were used for normally distributed data and Mann-Whitney U, Kruskal-Wallis, and Spearman correlations tests for nonparametric data. For BIVA bivariate group vector comparisons, the Hotelling's T^2 test and Mahalanobis distances (D) between groups were analyzed. T^2, *F*, *P*, D values are presented. A *P* value <0.05 was considered statistically significant.

Results

Participants

Study participants were predominantly white (2 men were Asian-Indian). In all, there were 69 participants (44 men and 25 women), with a mean age of 81.2 $\pm$ 7.4 y (age range: 62–96 y). Full participant details can be found in Table 1.

The mean BMI was significantly higher in women than in men (28 versus 24.7 kg/m^2), as was R/H (334 versus 296 Ω/m). Furthermore, the proportion of women within low-risk malnutrition score categories was numerically higher than men.