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Phase angle is related to outcome after ICU admission; an observational study

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SUMMARY

Introduction: Malnutrition at the time of ICU admission is associated with an increased morbidity and mortality. Malnutrition is most often assessed by a questionnaire but can also be determined with bio-impedance and measurement of phase angle.
In a single-centre observational study we compared the percentage of malnutrition in patients admitted to our ICU, according to the Short Nutritional Assessment Questionnaire (SNAQ) with the phase angle measured with bio-impedance. Furthermore, we questioned whether malnutrition is related to outcome parameters.
Methods: In a 15 week period consecutive patients admitted to the ICU were included. Exclusion criteria included age <18 years, anatomical and/or neurological abnormalities of the limbs and an ICU stay less than 6 h. Bio-impedance measurements were performed shortly after admission, the SNAQ was obtained from the patient or legal representative. Malnutrition is considered with a SNAQ ≥2 or a phase angle of <5° for men and <4.6° for women. The study was approved by our local ethical committee (MCL, nWMO 77, April 18, 2015).
Results: 299 Patients were included (66% male, age 66 ± 12 year, BMI 27 ± 4 kg/m^2 and APACHE II score 14 [11–17]), of which 64% elective and 36% acute admissions. Hospital mortality was 7.4%. Malnutrition was present in 16% according to the SNAQ and in 36% according to phase angle. There was a fair accordance between the SNAQ and phase angle. Phase angle was significantly higher in patients with a SNAQ score of 0–1 (5.5°±1.3) in comparison with patients with a SNAQ score ≥2 (4.4°± 1.1) ($p < 0.001$). Logistic regression analysis showed a significant relation between SNAQ and BMI, malignant disease and hospital length of stay and between phase angle and age, sex, BMI, malignant disease, hospital length of stay and hospital mortality.
Conclusion: Malnutrition was present in 16% according to the SNAQ and in 36% according to phase angle in our IC population. Malnutrition was associated with prolonged hospital length of stay. In this small population of mixed ICU patients, a low phase angle was found to independently predict hospital mortality.
Clinical Trials.gov number: NCT02911181.

1. Introduction

Malnutrition at the time of hospital admission is associated with an increased morbidity and mortality [1–3]. This is also true for patients admitted to the Intensive Care Unit (ICU), and irrespective of the type of admission [4–7]. The reported prevalence of malnutrition in ICU patients varies from 17 to 78 percent in different patients groups and settings [7–9].

Malnutrition can be assessed by using validated questionnaires such as the Subjective Global Assessment (SGA), Malnutrition Universal Screening Tool (MUST) or the Nutrition Risk Screening 2002 (NRS-2002) [10–12]. In the Netherlands, the most frequent used screening method to assess the risk of malnutrition is the Short Nutritional Assessment Questionnaire (SNAQ) [13]. This questionnaire evaluates unintentional weight loss, decrease of appetite and the use of supplemental drinks or tube feeding. The

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results of the SNAQ score correspond well with the results of the MUST and NRS-2002 [14].

An alternative method to assess malnutrition is by means of bio-impedance measurements. By applying a low voltage alternating current the body resistance (R) and reactance (Xc) are measured and subsequently, the phase angle (PhA) is determined [15]. Phase angle can be seen as a marker of the amount and quality of soft tissue mass with higher values reflecting higher cellularity, cell membrane integrity and better cell function [16]. Phase angle has been studied in several disease states and is considered a useful marker of nutritional status [16–18]. Recent studies in ICU patients show an association between phase angle, nutritional status and outcome [19,20].

We conducted a single-centre observational study to establish the percentage of malnutrition in patients admitted to our ICU, according to the SNAQ score and the phase angle. We questioned whether there is an association between the presence of malnutrition according to the SNAQ score and the phase angle. Is malnutrition, measured with the SNAQ score or phase angle, related to outcome parameters such as length of stay (ICU and hospital) and survival.

2. Methods

2.1. Study design

We performed a single-centre prospective, observational study in a closed-format, 20-bed, mixed ICU in a tertiary teaching hospital. The study was conducted in a 15-week period from February until June 2016. We included consecutive patients >18 years of age who were admitted to the ICU during this period with an expected ICU stay >6 h.

Patients diagnosed with neurological diseases with paresis or paralysis of the limbs, anatomical or vascular abnormalities to the limbs or skin abnormalities at the site of measurement were excluded.

The study was approved by the local Medical Ethics Committee (Regional Review Committee Patient-related Research, Medical Centre Leeuwarden, nWMO 77, April 18th, 2015) and has been performed in accordance with the ethical standard laid down in the Declaration of Helsinki and its later amendments. Informed consent was waived under the condition that no extra blood samples or measurements other than protocolized, standard care were performed. The study was registered in a public register (ClinicalTrials.gov, number NCT02911181).

2.2. Data collection

At the time of admission on the ICU clinical parameters and blood samples were collected according to the standard protocol. Collected parameters were demographic data, reason for admission (medical or surgical, acute or elective), body mass index (BMI; calculated from measured weight and height; weight(kg)/height^2(m^2)), the APACHE (Acute Physiology And Chronic Health Evaluation) II score, the presence of chronic diseases (Diabetes Mellitus, Chronic Obstructive Pulmonary Disease, Chronic Kidney Failure and active malignant disease), laboratory measurements (C-reactive protein, creatinine and albumin) and length of stay (ICU and hospital) and survival (ICU and hospital).

Preferably, the bio-impedance measurement was performed shortly after admission but no later than 24 h after ICU admission. The interview to obtain the questions for determination of the SNAQ score took place during stay on the ICU with the patient or his/her assigned representative within several days after ICU admission.

2.3. SNAQ score

The Short Nutritional Assessment Questionnaire (SNAQ) screens for risk of malnourishment according to criteria summarized in Fig. 1. By protocol, in all patients who are admitted to our hospital the SNAQ score is obtained and registered. Patients with a SNAQ score of 0 or 1 are categorized as well nourished, a score of 2 refers to moderate malnutrition and a score of 3 and higher indicates severe malnutrition [13].

2.4. Bio-impedance measurements

The bio-impedance measurements are based on the electrical principle that the body is a circuit with a given resistance (R; opposition of current flow through intracellular and extracellular solution) and reactance (Xc; capacitance of the cells to store energy) [21]. The arc tangent of Xc/R $((Xc/R) \times 180^{\circ}/\pi)$ is called the phase angle (PhA) and represents the phase difference between voltage and current [22]. A phase angle $\leq 5^{\circ}$ for men and $\leq 4{,}6^{\circ}$ for women is considered indicative for malnutrition [23].

For the measurements, electrodes are placed on the wrist and dorsal site of the hand and on the ipsilateral ankle and forefoot with a distance of at least 5 cm between the electrodes (Biatrodes, Akern Srl, Italy) [24]. Before placing the electrodes the skin is cleaned with ethanol 70%. Through the application of a 400 mV, 50-kHz current to the electrodes the resistance (R), the reactance (Xc) and the phase angle are measured (BIA 101 Anniversary Sport Edition analyser, Akern Srl, Italy). The procedure is safe and not burdensome for the patient.

2.5. Statistical analysis

Descriptive statistics will be used to describe the study population. Data are shown as mean with standard deviation or median with IQR, according to their distribution. For comparison between groups the Students T-test was used for parameters with a normal distribution and the Mann Whitney U test for parameters with an abnormal distribution.

We used the ANOVA (backward stepwise method), a multivariate analysis, to correct for differences in baseline characteristics. All variables with a p-value < 0.25 in the univariate analysis were included. A two-sided P value < 0.05 was considered significant. Bonferroni correction was used for multiple testing. All tests of the

Questions	Yes/no	Points by yes
Unintentional weight loss: -Over 6 kg in 6 month time -Over 3 kg in the last month	yes/no	 3 2
Loss of appetite?	yes/no	1
Use of supplemental drinks or tube feeding over the last month	yes/no	1
BMI (weight/lenght^2) < 18.5	yes/no	3

Fig. 1. Short Nutritional Assessment Questionnaire (SNAQ).

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