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Research paper

Performance evaluation of phase angle and handgrip strength in patients undergoing cardiac surgery: Prospective cohort study

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ABSTRACT

Background and aims: The phase angle (PA), derived from bioelectrical impedance analysis (BIA), has been interpreted as a cell membrane integrity indicator, while handgrip strength (HGS) has been used as a prognostic indicator in certain clinical situations, such as in cardiac, oncologic patients with renal disease, hemodialysis patients, HIV-positive patients, and liver disease patients. In addition to prognostic scores, body changes due to surgical procedures indicate the importance of measuring muscle function and cell integrity. This study aimed to evaluate the behaviour of PA and HGS in patients undergoing cardiac surgery and associate these factors with clinical outcomes and prognosis.
Methods: This was a prospective cohort study of 50 consecutively recruited patients (aged ≥18 years) undergoing cardiac surgery. Measures PA and HGS were at three set points: preoperative, at hospital discharge and three months postoperative. The following data were collected: time of cardiopulmonary bypass (CPB), ischemia, mechanical ventilation (MV), Intensive Care Unit (ICU) length of stay (LOS) and hospital LOS after surgery; the EuroSCORE was also calculated.
Results: A decrease in PA was observed between the preoperative and the two postoperative stages ($p < 0.001$). There was a reduction in HGS between the preoperative and hospital discharge assessments ($p < 0.001$) and a recovery three months postoperative ($p < 0.001$). The MV and EuroSCORE were inversely associated with PA and HGS in all three assessments. The PA was correlated with EuroSCORE in the first assessment ($p = 0.007$) and in the second and third assessments ($p < 0.001$), as well as with MV in all three assessments ($p < 0.001$). The HGS was correlated with EuroSCORE and MV in the first and second assessments ($p < 0.001$) and in the third assessment ($p = 0.010$ and $p = 0.018$, respectively).
Conclusion: PA and HGS appear to be related to MV time, ICU LOS and hospital LOS after surgery in patients undergoing cardiac surgery.

1. Introduction

Several risk stratification models have been proposed for predicting mortality in cardiac surgery.[1–3] Among the existing scores for estimating the risk of death in cardiac surgery patients, the Euro-

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pean System for Cardiac Operative Risk Evaluation (EuroSCORE) is the most utilised.[4,5] This model defines the risk of early mortality after cardiac surgery and stratifies patients into three risk groups: low (score 0–2), medium[3–5] and high (>6).[6] This model has demonstrated excellent specificity and sensitivity. The model has also been used outside Europe outperforming simple scoring systems.[7,8]

In addition to the use of prognostic scores, body changes due to surgical procedures indicate the importance of measuring preoperative and postoperative muscle function, both to understand the dynamics of the therapeutic process and to plan for necessary interventions, potentially preventing functional limitations from developing.[9]

In this context, handgrip strength (HGS) has been considered a useful functional capacity test for evaluating muscle strength in the general population, in addition to hospitalised and non-hospitalised persons with illnesses.[10–13] The HGS is measured with a dynamometer, which is a non-invasive, simple and quick method that can be used in clinical and epidemiological studies.[13] It has been studied in the clinical environment and as a diagnostic tool for assessing malnutrition, overall nutritional risk and mortality.[14–17]

Phase angle (PA), which is derived from bioelectrical impedance analysis (BIA), is another clinical outcome parameter.[18,19] The practical, non-invasive method can be measured at the bedside[20] and is commonly used to assess body composition.[21] The BIA is a measure of total body resistance to a low amplitude (800 μA), single frequency (50 kHz) electrical current; it includes properties such as impedance (Z), resistance (R) and reactance (Xc).[22] The PA is obtained through a ratio of R and Xc (PA = arctangent Xc/R) and reflects cell stability and water distribution in intra and extracellular spaces.[22] It has also been interpreted as an indicator of membrane integrity, a body cell mass predictor[21] and a prognostic indicator in certain clinical situations and serious diseases,[19,23–29] which suggests that it may be an important tool for estimating clinical outcomes or for monitoring cardiac surgical patients.

The aim of this study was to evaluate the behaviour of PA in relation to BIA and HGS over time in patients undergoing cardiac surgery and to associate them with the EuroSCORE to measure length of assisted mechanical ventilation (MV), intensive care unit (ICU) length of stay (LOS) and hospital LOS.

2. Methods

This was a prospective cohort study at the Hospital de Clínicas de Porto Alegre (HCPA), Brazil, between January 2015 and October 2015. Patients were recruited consecutively from the Cardiovascular Surgery Service surgery schedule through a personal invitation by the investigator. The criteria for inclusion were: elective cardiac surgery (isolated valve replacement surgery or coronary artery bypass grafting — CABG), age ≥ 18 years and informed consent to participate in the study. The exclusion criteria were: pregnancy, ascites, anasarca, cardiac reoperation within three months or impediments to BIA (i.e. cardiac devices, amputees and skin integrity issues). The informed consent was obtained from the patient or legal guardian.

The EuroSCORE was calculated and the following variables collected: surgery time (in minutes), cardiopulmonary bypass (CPB) (in minutes), aortic cross-clamp (in minutes), MV (in minutes), ICU LOS (days) and hospital LOS after surgery (days).

The initial BIA measurement was performed as close to the preoperative admission time as possible after the patient had fasted for four hours, and the latest time permitted was 24 h after admission. The second measurement occurred within 24 h of the planned hospital discharge, and the third and final measurement was taken three months after surgery. Except for the first assessment, which depended on admission time, the evaluations were performed in the morning before breakfast. The third BIA assessment was prescheduled and performed at the HCPA Clinical Research Center of the above-mentioned hospital. The PA was obtained through electrical bioimpedance, which was measured with a Biodynamics 450® analyzer, version 5.1 (Biodynamics Corp., Seattle, WA, USA), and resting ECG electrodes (tab style) (Conmed Corporation, Utica, NY, USA). The Biodynamics device requires the age, sex, weight and height of the patient to be entered. A digital scale was used (Líder, Araçatuba, SP, Brazil) to measure the patients' body weight, and a wall-mounted vertical anthropometer (Sanny, Sao Bernardo do Campo, SP, Brazil) was used to measure their height.

The BIA was performed with the patient lying supine on a bed with legs apart and arms not touching the torso. Four electrodes (two each on the right hand and foot) were placed in specific locations according to BIA Protocol (the dorsal surface of the right wrist, the third metacarpal, the surface of the right anterior ankle between the prominent bones, and the dorsal surface of the third metatarsal).[22] The HGS was assessed at three time intervals (preoperatively, 24 h prior to hospital discharge and three months after surgery) with a hydraulic hand dynamometer (Jamar, São Paulo, SP, Brazil). The tests were conducted by a researcher with the patient sitting with their elbow flexed to 90° and pressing the dynamometer with the dominant hand at full strength for three seconds (94% were right-handed). The measurements were repeated three times and the highest value being used.[11,30] All BIA and HGS assessments were carried out by a single trained investigator familiar with the techniques and ICU routines.

The study adhered to the ethical principles of research involving human subjects outlined in the Declaration of Helsinki and was approved by the HCPA Research Ethics Committee (protocol 140698).

2.1. Statistical analysis

The Kolmogorov–Smirnov test was used to verify the normality of the distributions of the variables. Categorical variables were expressed as absolute or relative frequencies, and continuous variables were expressed as as mean and standard deviation or median and interquartile range, as appropriate. The Spearman or Pearson correlation coefficient was used to test correlations. Generalised estimating equations were used to evaluate PA and HGS changes over time. The Bonferroni post-hoc test was used when the main effect was significant. These variables were also analysed by subdividing patients into valve or CABG surgery. Linear regression was performed to assess the effect of the variables (gender, age, EuroSCORE, bleeding, CPB time, aortic cross-clamp time, MV time, ICU LOS and hospital LOS after surgery) on PA and HGS. All statistical analyses were performed with Statistical Package for Social Sciences, version 18.0 (SPSS, Inc., Chicago, IL, USA), and a p-value ≤ 0.05 was considered statistically significant.

To obtain a statistical power of 90%, assuming a standard deviation for PA variations of 1.0 at time 1 and time 2, with a difference of 0.5 between the times, the required sample size was 44 patients.

3. Results

Among the 106 patients eligible for the study, 26 were excluded and 30 were lost to follow up (refusals, deaths or abandonment), resulting in 50 patients with data for analysis.

The patient profiles and clinical outcomes are summarised in Table 1. There was a predominance of patients who underwent CABG and were male gender. EuroSCORE classifications resulted in 12 (24%) patients being considered as low risk, 25 (50%) medium risk and 13 (26%) high risk of mortality from cardiac surgery.

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