Bioelectrical Impedance Analysis in Cardiac Surgery
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Citation

Abstract
Bioelectrical multi frequency analysis (BIA) is a non-invasive method for estimation of body compartments based on the property of tissues to conduct electrical current. In this study 80 patients underwent elective CABG were examined. Pre- and postoperative resistance, reactance and phase angle were measured at 1, 5, 50 and 100 kHz using a four skin electrode technique. From this data total body water (TBW), intra/extracellular water (ICW/ECW), body cell mass (BCM), extracellular mass (ECM), lean body mass (LBM), cell rate, Meta and Kapa-Index were calculated. Simultaneous all data of patients, anaesthesia and perfusion were documented.

Preoperative results of BIA were found to be normal in more than 90%. Four and 24h postoperative a significant decrease in bioelectrical indices could be detected associated with an increase of TBW, ICW and ECW values. BCM, ECM, LBM, ECM/BCM-Index and ECW/ICW ratio showed a noticeable enhancement. A reduction of cell rate, Meta and Kapa-Index was observed postoperatively.

The results suggest that BIA represents an eligible method for assessment of fluid shift and changes in body composition induced by cardiac surgery. The implementation of this procedure could be evolving as a bedside tool to monitor postoperative fluid distribution.

INTRODUCTION
Every use of ECC during cardiac surgery leads to a systemic inflammatory reaction in combination with body fluid shift. One reason for changes in fluid status is well known as a “capillary leak syndrome”. Edemas in various vital parts are regarded as clinical signs. Extensive knowledge of fluid distribution therefore is a precondition of postoperative volume therapy. A small range of not invasive methods for perioperative fluid monitoring is available.

Bioelectrical impedance analysis (BIA) provides a non-invasive opportunity to quantify body fluid distribution [1]. The technique is based on the property of tissues to conduct alternating current and inversely body impedance.

BIA has an extended history in medical science and is validated in numerous publications, but only a few applications in cardiac surgery have been published [2-10].

This study was designed to examine CABG patients using BIA representing body fluid shift.

MATERIAL AND METHODS
The study includes 75 patients (52 male and 23 female, 47 – 75 years old) scheduled for elective coronary bypass grafting February until September 2001. BIA was performed the day before operation, 4h and 24 h postoperatively. Target criteria were results of bioelectrical impedance examination, particularly total body water (TBW), extra- and intracellular water (ECW/ICW). Attendant criteria were patient data, protocol of anaesthesia and cardio engineering and routine lab. The measurement took place with the BIA 2000-M multi-frequency analyser from the Data Input company, the evaluation succeeded with the Nutri 4 Body Composition Software. Statistical evaluation were realised with SPSS, Microsoft excel and qui-quadratic test.
BIOELECTRICAL IMPEDANCE ANALYSIS
Bioelectrical impedance analysis is a quick, easy non-invasive electric resistant determination to estimate body composition. It is reliable and applicable to individuals of almost all ages. Using a four-electrode technique on hands and feet an electric field is produced and the alternating current impedance consists of resistance (Rx) and reactance (Xc) as well as phase shift of the alternating current are measured. To understand the use of bioelectrical impedance in assessing body composition, it is necessary to understand some basic physical information related to impedance.

IMPEDANCE
Impedance is the frequency-dependent opposition of a conductor to the flow of an alternating electric current. A measure of impedance (Z) is composed of two vectors, resistance (Rx) and reactance (Xc).

RESISTANCE
Resistance is the pure opposition of a conductor to an alternating current. It is inversely proportional to total body water. Rx performs an excellent measure for assessment of total body water.

REACTANCE
Reactance is the component that results from the additional opposition to the flow of an alternating current produced by the capacitant effect of cell membranes, tissue interfaces and nonionic tissues. Xc is an important variable for calculation of body cell mass.

PHASE ANGLE
Differentiation of resistance and reactance is possible due to the phase-sensitive electronics assembly of BIA equipment. Capacitors of alternating current circuit leads to time change delta t. The time change is measured in degrees and termed as phase angle phi. Pure cell membranes would have a phase angle of 90°, pure electrolyte water of 0°. Phase angle therefore is directly proportional to body cell mass quite independent of technical source of error.

RESULTS
Preoperative measurement of bioelectrical impedance was found to be normal in more than 90% of patients, TBW = 41,5±8,4%, ECW = 16,1±2,9%, ICW = 26,3±5,5% represented as median and standard deviation.

Four hours after ECC we can see a significant increase of TBW = 47±7,9% (p = 0,05). Delta TBW accounts for 3,5% 4h and 4,5% 24 h postoperatively [fig. 1].

Figure 1

ECW shows a significant enhancement 4h and 24h after ECC compared to preoperative results, 16,1±2,3, 18,4±2,7 and 19,8±2,8% respectively. The increase of ICW 26,3±5,0% (praeop.), 26,2±5,5% (4h), 27,2±5,3% (24h) respectively is considerably lower [fig. 2].

Figure 2

Range of phase angle phi was found to be normal at all measured times, but there is a clear decrease 4h and 24h postoperatively, 6,3°±1,7°, 5,2°±0,9°, 5,0°±1,0° (normal range 5,0° - 9,0°) [fig. 3].
RESULTS

Meta-Index: 18.9±4.2, 16.6±3.7, 15.3±3.3 respectively, Kapa-Index: 2.0±0.5, 1.5±0.3, 1.3±0.3 respectively.

DISCUSSION

Changes in fluid distribution using extracorporeal circulation systems are common and well known. Direct methods for estimation of body composition and fluid shifting do not exist. For indirect measurement of body composition body components like total body water, lean body mass or body cell mass are used [20]. Known techniques are f.e. dilution methods, potassium measurement in the total body counter or densiometric measurement.

Bioelectrical impedance analysis represents a simple and low-cost bedside-tool for estimation of fluid accumulation [3,6,12,13]. In the present study 75 CABG patients were examined by means of BIA to investigate changes in body composition and fluid distribution caused by ECC.

A significant decrease of measured body impedance was assessed postoperatively in agreement with published literature [4,15,16]. Increase of calculated ECW is higher than ICW. Regardless of differences in extracellular water and interstitial fluid, ECW gives an account of predisposition of edema because is it made up mainly of lymph, interstitial and transstitial fluid and plasma respectively. Thus ECW can be considered as a parameter for measurement of edema caused by “capillary leak syndrome” [13].

Meta-Index is the ratio of resistance to body mass index. Calculating this index one can receive a prediction of electrical conductivity and the content of water and electrolytes of lean body mass. Reduction of the Meta-Index as found in the study argues for the accumulation of sodium bonded water. Kapa-Index, the ratio of reactance to lean body mass, corresponds approximately the mass of cell membranes per body mass index and the cell density of lean body mass, respectively. A significant shift of the value would be helpful for differentiation of ICW if BCM is reduced but this is not be available in the present study.

In conclusion BIA represents an interesting, non-invasive tool for estimation of fluid distribution using ECC.

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