Method and Reference Values for Early Detection of Lower Extremity Edema

Maria Labra OMS-1, Andrea Alvarez OMS-1, HN Mayrovitz PhD
Nova Southeastern University, Dr. Kiran C. Patel College of Osteopathic Medicine Ft. Lauderdale FL 33328

Background

A common symptom of congestive heart failure is lower extremity edema, usually bilateral, that affects foot dorsum, ankle and lower leg. Once edema is visualized the causative process is usually well established. However, there is no convenient method to detect early and potentially insidious changes in fluid content of these regions. A non-invasive way to assess local skin water is by measuring skin tissue dielectric constant (TDC) since TDC depends strongly on skin-to-fat water content. Because of patient-to-patient variability in TDC, it is difficult to use TDC directly to assess sub-clinical or low early levels of edema. But, if a normalized patient related parameter were identified and characterized then this obstacle might be overcome. It was hypothesized that the ratio of lower to upper limb TDC values is such a parameter.

Objectives

The purpose of this study was to obtain such reference values in healthy persons. Specifically, we hypothesized that the ratio of skin water in lower extremities to skin in arms that are not normally affected by CHF would provide a suitable index. For that purpose, skin tissue dielectric constant (TDC) was measured at 300 MHz as a direct index of skin tissue water at arm, hand, lower leg and foot bilaterally in self-reported healthy persons of various ages.

Subjects

A total of 44 subjects participated in this study. Males and females of any race were recruited. This group included subjects in the age range 18-30. Recruitment was done by word of mouth to volunteers that were willing to offer approximately 30 minutes of their time. Exclusion criteria for this study included: open skin wounds at sites of measurements, current or prior history of edema, currently pregnant, current or prior history of diabetes or congestive heart failure. Parameter indicators were the ratio of the lower extremity to upper extremity TDC value. These included foot dorsum/forearm (FF), foot dorsum/hand (FH), medial leg/hand (LH) and medial leg/forearm (LF). To date all participants encompass 88 ratios for each parameter have been evaluated to tissue depths of 0.5 mm and 2.5 mm.

TDC MEASUREMENTS:

Skin water was assessed by tissue dielectric constant measurements (TDC) at 300 MHz to approximate skin depths of 0.5 mm and 2.5 mm on five different anatomical sites: (Fig 1) hand, (Fig 2) forearm 4 cm distal to the antecubital fossa, dorsum of foot near 1st and 2nd toe, (Fig 4) medial leg and (Fig 3) lateral leg at about 6 cm above the malleolus. Each site measurement was repeated three times and averaged.

BIOPERMANDEANCE MEASUREMENTS:

Body composition of each subject was measured using Ironman InnerScan body Composition monitor (Fig. 5 & 6b). It is a battery operated device that measures the electrical impedance while the subject stands. The subject’s gender, birth date, and height are entered into the device after which the subject steps onto the scale and grips two attached handles for a period of about 15 seconds. Measured parameters include: total body weight, total body fat %, total body water %, and fat percentages of limb segmental values (left arm, right arm, left leg, right left).

Results

Data is for subjects under age 30 with dominant and non-dominant ratios combined. Leg data corresponds to the medial leg site and all results shown are for TDC measurements to a depth of 2.5 mm. Data showed that TDC values did not significantly differ between dominant and non-dominant sides at any site for either gender. However, TDC values were greater for males at forearm (33.3 ± 3.2 vs. 27.5 ± 3.0, p<0.001) and foot dorsum (32.3 ± 4.9 vs. 28.1 ± 2.8, p< 0.001). There was no gender related differences at the other measured sites with the largest TDC value measured at the hand (42.1 ± 7.9). The LL/UL ratios were normally distributed and varied depending on sites included in the ratio. However, the LL/UL ratio that had the least variance among subjects and also did not differ between genders, was the foot/forearm ratio. For measurements in 44 subjects (88 legs) the foot/forearm ratio was 1.03 ± 0.146 with a median value of 1.004.

Conclusions

The present findings suggest that measurement of the foot/forearm TDC ratio may provide a useful assessment parameter for detecting early lower extremity edema when that ratio exceeds a specified threshold greater than determined in the present healthy group. At this time, the optimum threshold value is somewhat arbitrary but a reasonable selection would be a value that is greater than the currently determined mean value plus 2SD. This would define a threshold for edema as a foot/forearm ratio greater than 1.300. This threshold provides a start point, but its suitability needs to be tested prospectively by TDC measurements of patients with a diagnosis of congestive heart failure and such is envisioned as the next research effort.

Selected References