SESSION 3

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Dehydration in geriatric patients and bioimpedance analysis

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Dehydration is a major problem of healthcare of the older population. Epidemiologic data suggest a prevalence of about 10% in the general older population and of about 30% in nursing home residents. Although dehydration is very common, there is no generally accepted definition and the diagnostic criteria are uncertain. Several clinical signs of dehydration, such as dry mouth or persisting skin folds, are not specific and have low sensitivity. The best clinical marker is a dry axilla with a specificity of 82% and a sensitivity of 50%. Laboratory data reflecting renal function and hydration status may be more precise, but they are influenced to a great extent by renal function and nutrition. Osmolarity of plasma is a good marker of pure fluid loss but it does not reflect the loss of salt and water, which is very common in older patients.

As bioelectric impedance analysis (BIA) agrees well with reference methods in the evaluation of total body water (TBW) in healthy subjects, there is hope that BIA may contribute to an objective diagnosis of dehydration. Up to now, only few studies have been performed to verify the diagnostic usefulness of BIA in assessing hydration status. Studies in patients undergoing hemodialysis have demonstrated that BIA is a useful and valid tool in assessing shifts of TBW in a longitudinal and intraindividual approach. However, the diagnostic value of single measurements seems to be very low. The only study comparing BIA measurements with the clinical judgment of hydration status in older patients demonstrated a poor level of agreement. Reasons for this low concordance are various. BIA is measuring the conductivity of the human body, which is dependent on the content of water and electrolytes. Many patients show disturbances of electrolytes such a hyponatremia, leading to falsely low measurements of hydration. In addition, TBW is very much dependent on the relation of fat mass (FM) and fat-free mass (FFM) of each individual. Fat is nearly free of water, whereas FFM consists of 73% water. As older persons show a great variance of body composition, i.e. relation of FM and FFM, measurement of TBW can hardly reflect hydration status without being certain about the exact FFM.

While BIA is an elegant technique of body composition analysis in healthy subjects, its application has several limitations in patients and in evaluating hydration status. Thus, future developments may overcome these limitations.

Key words: geriatric, dehydration, bioelectric impedance analysis.

Evolution of the assessment of hydration status: eliminating the problems and advancing the practice with bioimpedance

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Non-invasive assessment of hydration status remains a critical need in clinical medicine, particularly in acute settings. An increase of 3-4 L is detectable as pitting edema whereas a sub-clinical increase in fluid volume without edema and mild to moderate dehydration are difficult to diagnose. Traditional methods to assess hydration status including isotope dilution are not amenable for point-of-care use, and standard clinical evaluation methods (e.g., physical examination, laboratory studies and change in body weight) are either impractical or insensitive to discriminate normal from altered hydration status for an individual.

A noninvasive approach introduces a safe, radio-frequency alternating current and measures passive electrical characteristics of the body to classify acutely and monitor serially the hydration status of individuals. The use of alternating current and single (50 kHz) frequency with multiple regression equations to predict total body water (TBW) or extracellular water (ECW), or multiple (2 kHz to 2 MHz) frequencies and *in vitro* biophysical models (Cole and Hanai) to calculate TBW and ECW and approximate intracellular water (ICW) results in estimated fluid volumes that are too imprecise for clinical use.

Contemporary bioimpedance methods overcome these limitations derived from questionable assumptions of constancy of composition of the fat-free body and the imprecision of mathematical prediction models, based on body weight, to classify (under-, normal or overhydration) and rank (more or less than before intervention) hydration status. They use 50-kHz measurements of whole-body resistance (R) and reactance (Xc), normalized for standing height and plotted on the RXc graph to illustrate an impedance vector that has length, which is inversely related to TBW, and direction, characterized by the phase angle (arc tan Xc/R) that indicates tissue hydration status and cell mass. This method is termed bioimpedance vector analysis (BIVA). Vector position on the RXc graph is interpreted relative to the bivariate distribution R/H and Xc/H of vectors derived in healthy people and expressed as 50, 75 and 95% confidence intervals shown as ellipses. Individual vectors outside of the upper pole of the 50% ellipse are classified as dehydration whereas vectors outside of the lower pole of the 50% tolerance ellipse are described as fluid overload. Changes in tissue hydration status less than 500 mL can be detected with BIVA. The principal use of BIVA is the assessment of hydration status in patients with fluid

overload or dehydration, which is helpful in the prescription of treatment.

An alternate application of bioimpedance measurements is the comparison of the individual R, Xc, impedance, and phase angle values with normative data (ranges) from a healthy population based on gender and age. Because impedance and R values indicate TBW and ECW, respectively, interpretation of individual measurements utilizes the biometric of "at, below or above" the expected values for the healthy population. This application recently was modified to include Z-scores for an individual to classify hydration status as well as nutritional status assessment and muscle function among hospitalized and elderly patients.

The practical advantages and clinical value of bioimpedance measurements to identify alterations in hydration status acutely and serially emphasize the opportunities for its use in other applications including surveillance and monitoring effects of intervention.

Key words: resistance, reactance, bioimpedance vector analysis, impedance spectroscopy.

CONFERENCE

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Hydration, morbidity and mortality in vulnerable populations

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Deprivation of water for more than a few days inevitably leads to death, though there are occasional reports of much longer survival without access to water in exceptional situations, highlighting the individual susceptibility to the effects of absence of water intake. Such extreme conditions, however, are seldom encountered in daily living for most of the population. It is normal for small fluctuations in body water content to occur throughout the day with no perceptible effect on health or performance. Losses incurred due to sweating, respiratory loss, through vomiting and in urine and stools, are replaced through the intake of fluids and foods at intervals throughout the day. Chronic mild dehydration may be common in some population groups, including especially the elderly.There may be an association, although not necessarily a causal one, between low habitual fluid intake and some chronic diseases, including urolithiasis, constipation, asthma, cardiovascular disease, diabetic hyperglycaemia, and some cancers. Acute hypohydration is recognised by many clinicians as a precipitating factor in a number of acute medical conditions in the elderly. The risk of infection in the elderly has also been linked to poor fluid status, and the mortality rate can be as high as 50% in the absence of early diagnosis. According to analysis of the death certificates of care home residents in England and Wales between 2005 and 2009 carried out by the Office for National Statistics, dehydration was responsible for 667 deaths during this period, compared to 157 that were ascribed to malnutrition. Impairments of cognitive function may occur at moderate levels of hypohydration, but the methodology in many of these studies is poor, both with regard to assessment of hydration status and to the functional tests applied. Even short periods of fluid restriction leading to a loss of body mass of 1-2%, however, lead to reductions in the subjective perception of alertness and ability to concentrate and to increases in self-reported tiredness and headache. In the elderly with already impaired function this may lead to a spiral of further reductions in fluid intake, and there is some evidence of an association between functional status, as assessed by the Barthel index, and water turnover. The most vulnerable individuals may receive more attention from staff, while those with moderate levels of impairment may be at greater risk of inappropriate fluid intake. Overhydration is not always benign and may be associated with bone loss and increased fracture risk in the elderly. Though there is limited published information, and added heat stress may increase symptoms in susceptible individuals. Epidemiological evidence from patterns of morbidity and mortality suggest that all-cause mortality is increased when high temperatures persist for more than a few days. The limitations of this evidence must be recognised, and it seems likely that the number of heat fatalities is underreported due to lack of reports. In the last decade or so, a very substantial number of papers have been published with analysis of patterns of morbidity and mortality during periods of exceptional weather, with the primary focus of most of these studies being on very high, rather than low, environmental temperatures. The elderly are most vulnerable to periods of extreme heat, and young children may also show to be susceptible, but effect is seen across the whole age range. At least part of the mortality observed during a heat wave is the result of a harvesting effect, also referred to as *short-term forward mortality displacement*. It has been observed that for some heat waves, there is a compensatory decrease in overall mortality during the subsequent weeks after a heat wave. Such compensatory reduction in mortality suggests that heat affects especially those so ill that they “would have died in the short term anyway”. In other surveys, however, no such effect has been established, suggesting that is not simply an elimination of the most susceptible individuals. Epidemiological surveys cannot establish causal relationships, and there seem to have been few attempts to analyse the effectiveness of the preventive measures that have been implemented in the aftermath of major heat waves. Even though some of the evidence is not entirely consistent, prudence suggests that it may be wise to maintain good hydration status.

Key words: euhydration, dehydration, overhydration, morbidity, mortality.