Role of Bioimpedance Vectorial Analysis in Cardio-Renal Syndromes

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Summary: The cardio-renal syndromes (CRS) are the result of complex bidirectional organ cross-talk between the heart and kidney, with tremendous overlap of diseases such as coronary heart disease, heart failure (HF), and renal dysfunction in the same patient. Volume overload plays an important role in the pathophysiology of CRS. The appropriate treatment of overhydration, particularly in HF and in chronic kidney disease, has been associated with improved outcomes and blood pressure control. Clinical examination alone is often insufficient for accurate assessment of volume status because significant volume overload can exist even in the absence of peripheral or pulmonary edema on physical examination or radiography. Bioelectrical impedance techniques increasingly are being used in the management of patients with HF and those on chronic dialysis. These methods provide more objective estimates of volume status in such patients. Used in conjunction with standard clinical assessment and biomarkers such as the natriuretic peptides, bioimpedance analysis may be useful in guiding pharmacologic and ultrafiltration therapies and subsequently restoring such patients to a euvolemic or optivolemic state. In this article, we review the use of these techniques in CRS.
Semin Nephrol 32:93-99
Keywords: Bioimpedance vectorial analysis, cardio-renal syndromes, acute heart failure, chronic kidney disease

Over the past decade, many cardiologists, intensivists, and nephrologists have shown keen interest in pathophysiology of this organ cross-talk between heart and kidney. The interaction between the heart and kidney is complex, with tremendous overlap of diseases such as coronary heart disease, heart failure (HF), and renal dysfunction in the same patient. To address the inherent complexity of cardio-renal syndrome (CRS) and to stress the bidirectional nature of the interactions between the heart and kidneys, a simple classification into five subtypes reflecting their primary/secondary pathologies, as well as time frame, was proposed. This classification is reviewed in further detail in a separate article in this issue, and in other reviews.[1-3]

Bioelectrical impedance techniques increasingly are being used in the management of patients with end-stage renal disease (ESRD) and those with HF. These methods provide more objective estimates of volume status in such patients, as an adjunct to standard clinical assessment. In this article, we review the use of these techniques in the clinical settings of chronic dialysis and acute HF.

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Financial support for this work: none.
Financial disclosure and conflict of interest statements: Dr. Claudio Ronco receives speaking honoraria from Alere, Abbot, Gambro and Pfizer.
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0270-9295/ - see front matter

doi:10.1016/j.semnephrol.2011.11.012

BIOELECTRICAL IMPEDANCE ANALYSIS IN ACUTE HEART FAILURE

Acute heart failure (AHF) is a complex hemodynamic disorder, with the majority of hospitalized patients presenting with fluid overload.[4] The initial treatment of patients includes relief of congestion and restoration of hemodynamic stability to prevent renal dysfunction. CRS type 1, often described in the literature with the term "worsening renal function" (WRF), is a common complication of AHF with the reported incidence ranging from 24% to 45% in hospitalized patients.[5] Several clinical factors have been shown to be associated with increased risk for WRF including male sex, renal dysfunction at the time of hospital admission, more severe HF (ie, worse New York Heart Association class, lower left ventricular ejection fraction, or presence of pulmonary edema), tachyarrhythmias, and increased blood pressure at hospital admission. Similarly, several therapy-related factors have shown association with WRF including high-dose diuretic and/or vasodilator therapy.[6-8]

Despite clinical improvement it has been shown that most patients hospitalized for acute decompensated HF show evidence of volume overload at discharge.[4] Furthermore, subclinical volume expansion is related to disease progression and unfavorable outcomes.[9]

Currently, evidence and guidelines to assess congestion during hospitalization or predischarge are not well established. In fluid-overloaded patients standard monitoring includes the evaluation of clinical signs and symptoms, radiographic and body weight changes, and laboratory analysis.[10] The prognostic role of neurohumoral markers in AHF during the in-hospital phase is of great interest and clinical importance. Natriuretic peptides, released in response to volume and pressure overload,[11]

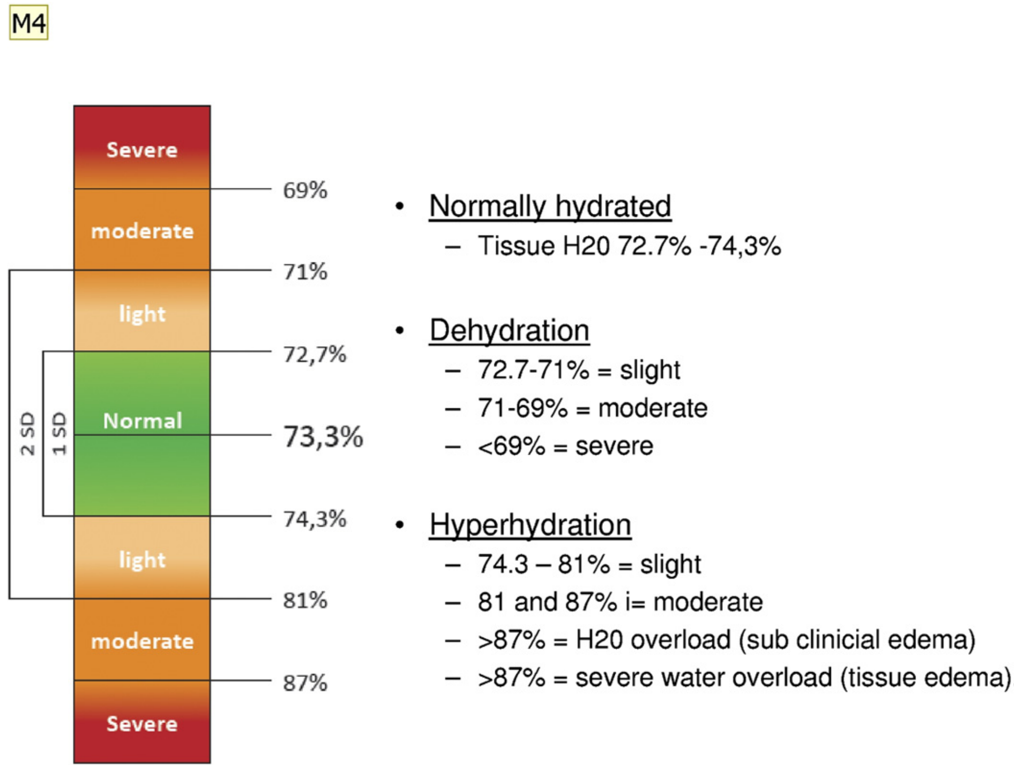

Figure 1. Graphic representation of the hydration state in the visual scale for BIVA.

have been proposed as a measure of congestion (wet brain natriuretic peptide (BNP) level).[12] However, growing evidence shows that hypervolemia by itself is associated independently with mortality.[13,14]

Most physicians determine hydration clinically by assessing the extracellular compartment (skin turgor, jugular venous distention, blood pressure). Parameters used to determine fluid volume include changes in body weight, haematologic indices (hematocrit, hemoglobin), urinary osmolarity, blood pressure, orthostatic tolerance, and heart rate.

Recently bioimpedance vectorial analysis (BIVA), a noninvasive method for measurement of body hydration status, has been suggested as a tool to assess the volume status in patients with HF. Measurement is easy, bedside, and useful in the decision-making process.[15] Using an alternating electrical current that is passed through the biologic tissue, BIVA evaluates total body hydration by resistance and reactance, visually presented as a nomogram and classifying patients into 3 classes: normally hydrated, overhydrated, or dehydrated (Figs. 1 and 2).[16,17] This technique has been used and validated in various disease conditions including ESRD and dialysis, which are discussed further later. In AHF, BIVA correlates with New York Heart Association class[18] and seems to be used to guide fluid-related therapies providing an accurate index of total body fluid.[15,19]

In a pilot study, Aspromonte et al[20] hypothesized that titration of treatment to reduce plasma BNP levels would be superior to treatment dictated by clinical acumen during hospital admission for AHF. The study population consisted of 184 patients (age, 76 ± 10 y, 49% men) enrolled after restoration of clinical stability and measurement of predischarge BNP. Patients with BNP less

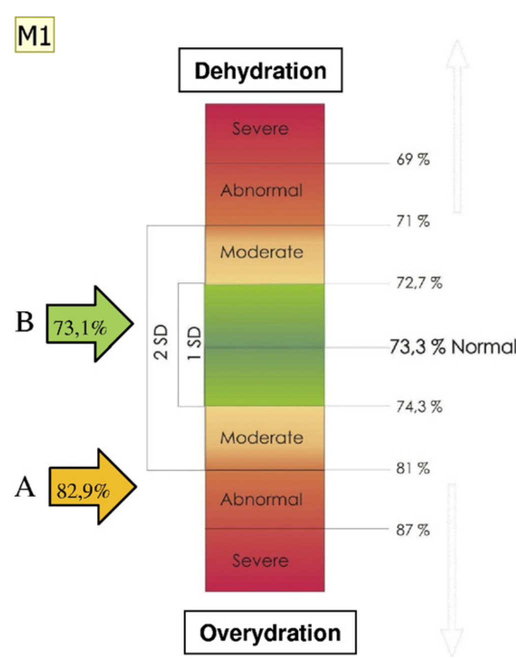

Figure 2. Typical example of migration in response to fluid depletion therapy. Arrow A indicates the hydration status of a patient with moderate-severe overhydration. Arrow B indicates a patient in a euvolemic state.