Accurate determination of fluid status in patients with heart failure is a critical aspect of care of this population. Early detection of emerging fluid overload would allow for prompt intervention, potentially aborting clinical deterioration and avoiding hospitalization. While many strategies are available to determine fluid status of patients, all areas are compromised by less-than-optimal sensitivity and specificity. Recent work on the role of bioimpedance as a means of assessing a patient’s fluid status indicates that this parameter may have a role in monitoring patients with heart failure. This article reviews present techniques available for assessment of fluid status and focuses on the additional information provided by bioimpedance assessment. Congest Heart Fail. 2010;16(4)(suppl 1):S52–S55. © 2010 Wiley Periodicals, Inc.

Ken McDonald, MD
Director, Heart Failure Services, St Vincent’s University Hospital and University College, Dublin, Ireland

Address for correspondence:
Ken McDonald, MD, Department of Cardiology, St Vincent’s University Hospital, Elm Park, Dublin 4, Ireland
E-mail: kenneth.mcdonald@ucd.ie
Manuscript received March 24, 2010; accepted April 8, 2010

Established Parameters for Assessment of Fluid Status in Heart Failure

Clinical Assessment. While compromised by subjectivity, both with the...
monitoring fluid status at the outpatient level

Figure. Morbidity burden in survivors of hospital admission for acute decompensated heart failure demonstrating the frequent development of threatened outpatient decompensation (UV) compared with episodes of readmission for heart failure (HF Adms) and non–heart failure–related causes (Non HF).

In summary, while clinical assessment is of importance in the setting of patients with possible clinical deterioration, it must be stressed that the absence of physical signs of fluid overload does not adequately rule out the diagnosis. In particular, it needs to be emphasized, especially to patients, that in evolving clinical deterioration weight gain may occur in smaller increments over longer periods and that in some circumstances may not register at 2 kg over 48 hours, which forms the basis of advice given to the patient. This underlines the need for complimentary investigations to help secure or rule out the diagnosis.

Chest Radiography. While chest radiography remains a frequently performed test in the assessment of emerging clinical deterioration, it has been well-demonstrated that normal findings on chest radiograph do not exclude fluid overload.6 The reasons for this are likely multiple, including technical issues relating to radiographic penetrance, body habitus, and also the likelihood that significant fluid overload is required for the standard chest radiographic signs of fluid overload to appear.

Therefore, its value in the investigation of possible decompensation in heart failure is to rule out alternative diagnoses such as respiratory infection, but in regard to fluid status it lacks sensitivity and is not an effective guide to use of diuretic therapy.

Natriuretic Peptide. Natriuretic peptide (NP) assessment is becoming increasingly used in the management of heart failure.7 The main role of this biomarker at present is in the initial diagnosis of heart failure, in defining prognosis in patients with established heart failure, and potentially as a guide to therapy. Whether NP may be helpful in the assessment of clinical deterioration in patients with an established heart failure is less clear. In heart failure patients presenting to the emergency department with significant dyspnea, elevated NP may be helpful in confirming the diagnosis. B-type natriuretic peptide levels in excess of 500 pg/mL are very suggestive of a heart failure diagnosis, while values <100 pg/mL provide a confident rule out value.8 However, certain caveats need to be taken into consideration when making this assessment. In patients with established heart failure, it
is important not to interpret an NP value in isolation, but to compare it to the patients most recent euvoletic value if available. There are 2 important reasons for this comparison: first, a patient’s euvoletic value may remain significantly elevated, and therefore assessment of an isolated value on presentation to the emergency department may lead to incorrect interpretation. Second, the reference change value for NP is quite large, of the order of 50% for B-type natriuretic peptide (BNP) and modestly less for N-terminal proBNP, indicating that such a change from a stable value is required to be certain that it is clinically significant. Therefore, substantial change from a clinically stable value, especially when the current value at the time of potential deterioration is >500 pg/mL, indicates evolving fluid retention.

However, the role of NP in the community setting to detect more subtle presentations earlier in the natural history of emerging clinical deterioration is less certain. Work from Lewin and colleagues demonstrated that combining weight change with alteration in impedance or vasodilator therapy.

**Invasive Measurements.** Invasive measurements remain the gold standard for assessing left-sided filling pressures. However, either the temporary placement of a Swan-Ganz catheter or the use of a chronic in dwelling pulmonary catheter is complicated by all the hazards of invasive procedure as well as costs.

**The Role of Bioimpedance Measurement**

It is clear from the above that while there are many approaches to the assessment and diagnosis of emerging fluid retention in patients with heart failure, all suffer from a lack of sensitivity and are compromised in their usefulness in guiding therapy. Therefore, further strategies are required. Given that the major concern is emerging fluid retention, attention has turned to the potential role of bioelectrical impedance. Impedance is a measure of resistance to flow of an electrical current. It can be measured by multiple methods and has been shown to accurately reflect hydration status in patients with renal, cardiac, and liver disease. Impedance is derived from 2 measurements, electrical resistance and reactance. As patients become fluid-overloaded, both of these parameters decrease, reflecting improved conductivity of electrical current.

**Invasive Methods.** Impedance values have been obtained from indwelling device therapies used in heart failure management such as defibrillators and cardiac resynchronization devices. Several reports have now demonstrated significant decreases in impedance values measured between the right ventricular lead and the device can, often observed up to weeks before the typical features of clinical deterioration present. This early warning would clearly be of benefit in our attempts to intervene at the earliest possible time to abort a threatened decompensation. False-positive readings can occur as a result of other thoracic pathologies such as pneumonia and hemothorax, which could reduce impedance values. However, while useful when available, it is likely not practical or cost-effective to place invasive devices for the sole purpose of measuring fluid status in heart failure patients.

**Noninvasive Methods.** Fortunately, several noninvasive techniques are also available to measure total body or regional impedance. A band electrode method has provided data on thoracic impedance in patients with heart failure and has demonstrated reduced values with impending congestion.

Kataoka reported on the role of a novel weighing scales incorporating measurement of bioelectrical impedance and analysis of total body fat. The author demonstrated that combining weight change with alteration in impedance or body fat percentage proved more accurate in determining clinical deterioration than body weight change alone.

Tetrapolar impedance plethysmography, with electrodes placed on the periphery of ipsilateral upper and lower limbs for whole body impedance and proximally on the limbs for segmental thoraco-abdominal impedance, has also...
been assessed in patients with heart failure. Parrinello and colleagues used this technique to assess fluid status in patients presenting to the emergency department with acute dyspnea of unclear cause. They observed that impedance and reactance measurements, either whole-body or segmental, accurately differentiated dyspnea from ADHF from non–heart failure–related dyspnea and normal controls. In addition, improvement in heart failure status during admission was mirrored by an increase in resistance and reactance and an overall increase in bioelectrical impedance. Furthermore, the authors demonstrated a strong correlation between impedance and natriuretic peptide levels. Finally, receiver operator curve analysis underlined the diagnostic accuracy of this technique with area under the curve values of 0.93 to 0.96 for total body and regional values. Patterna and colleagues assessed the value of impedance measurement in patients with refractory heart failure treated with furosemide and without hypertonic saline.19

Similar to Parrinello and colleagues, they demonstrated that impedance is reduced in ADHF, increases with effective therapy in heart failure, and does so in a manner similar to BNP.

Since impedance specifically measures fluid status, it may more accurately define volume status than other techniques outlined above. Potential pitfalls with noninvasive impedance measurement include the influence of pleural and abdominal cavity fluid on measurements. Furthermore, skin conditions can significantly alter readings.

**Perspective**

The above data indicate that monitoring bioelectrical impedance provides important incremental information on the fluid status of patients with heart failure. The information from invasive and noninvasive strategies indicates that this parameter may provide an earlier signal of evolving problems than presently available surveillance strategies such as weight monitoring. By identifying reduction in impedance weeks before clinical presentation, this approach underlines that significant changes are evolving remote from the time of clinical presentation, potentially allowing for earlier and more effective intervention. In addition, impedance values appear to track clinical response to intervention and therefore may allow for more precision in adjusting diuretic therapy. Development of a simple noninvasive system would further expand the role for this approach and potentially allow for patient home monitoring of this parameter, thus facilitating even earlier notification of impending problems, especially in high-risk patients.

**Disclosure:** Dr McDonald received an honorarium funded by an unrestricted educational grant from Abbott Laboratories and Otsuka America Pharmaceuticals for time and expertise spent in preparation of this article. He is a member of the Advisory Board of EFG Diagnostics Ltd, Belfast, Ireland.

---

**REFERENCES**


3. Dickstein K, Cohen-Solal A, Filippatos G, for Task Force for Diagnosis and Treatment of Acute and Chronic Heart Failure 2008 of European Society of Cardiology. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2008: the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2008 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (ESICM). Eur Heart J. 2008;29(19):2388–2442. Epub 2008 Sep 17.


