The incidence of heart failure (HF) is increasing worldwide and despite significant progression in pharmacological therapy, HF-related hospital admissions have also not decreased. The acute decompensation of HF induces irreversible disease progression and predicts poor prognosis. Although the mechanism of developing acute decompensation in HF remains to be unveiled, hypervolemia and altered left ventricular loading volume are thought to be important contributing factors. However, fluid accumulation often arises prior to the onset of symptoms. Conceptually, continuous monitoring of volume status in HF patients may help in the detection of subclinical hemodynamic deterioration (Figure 1), but early detection of volume retention in the clinical setting is often challenging. Conventional workups such as weight monitoring, chest X-ray, and echocardiography are useful but of limited use in validating each patient’s volume status. However, the recent progression of implantable cardioverter defibrillators (ICD) and cardiac resynchronization therapy/defibrillator device (CRT-D) suggest their potential use as methods for estimating fluid accumulation in the chest cavity by measuring intrathoracic impedance and providing additional insight into the difficult problem of managing HF patients.

In this issue of the Journal, Asada et al propose a novel clinical usage of impedance monitoring, namely detection of volume loss events. The FAST study, a retrospective study of 156 HF patients with ICD or CRT-D, demonstrated that impedance monitoring using OptiVol was more sensitive than conventional weight monitoring in predicting decompensation (76.4% vs. 22.5%). However, the SENSE-HF study, a prospective multicenter double-blind study, showed low sensitivity (42%) and a low positive predictive value (PPV 38%) of the OptiVol algorithm for impending HF. Thus, improvement in specificity and accuracy is expected from future studies.

In the management of HF, fluid loss derived from dehydration because of excessive use of diuretics or bleeding accompanied by anticoagulant or antiplatelet agent administration is often seen and can sometimes be prob-
Monitoring Volume Depletion in HF

Figure 2. Intrathoracic impedance is inversely correlated with pulmonary capillary wedge pressure (PCWP) and net fluid loss (revised from Yu et al7 with permission). Note that the PCWP ranges from >30mmHg to <10mmHg.

lematic.11 Contrary to the case of congestion, the authors presumed the intrathoracic impedance may increase in volume loss events and retrospectively assessed the association between intrathoracic impedance and volume loss events in 51 consecutive HF patients who underwent ICD or CRT-D implantation. It is noteworthy that they developed a totally new classification of the impedance changes. They classified the positive deviation of thoracic impedance (PDI), which may reflect volume depletion in the thoracic cavity, into 4 groups according to the peak level and duration: no PDI, small PDI, spike PDI, and large PDI. During the 1-year follow-up period, 237 PDI events and 98 volume loss events were recorded; subsequently, large PDI deviation >5 ohms for at least 4 days, was found to have a PPV as high as 100%. Considering the PPV of the OptiVol algorithm for predicting HF was only 38.1% in the SENSE-HF study, the impact of their high PPV of a large PDI should be emphasized. Although the authors do not discuss it, they also showed that the sensitivity of all PDI events for predicting volume loss events was 87.8%, meaning that patients without impedance elevation >3 ohms would possibly not be hypovolemic. In addition, the authors made another interesting attempt to score the severity of volume loss events according to required medical interventions. Their findings demonstrated that both the peak level and the duration of PDI were significantly associated with the volume loss event severity score. This indicates that the higher or longer the PDI, the more advanced the care provided in the future.

In summary, to the best of our knowledge, this is the very first study to demonstrate the clinical feasibility and utility of continuous thoracic impedance monitoring to predict volume loss events in HF patients. Continuous intrathoracic impedance monitoring using ICD or CRT-D is widespread in the clinical setting, but the conventional fluid index seems currently unable to achieve a satisfactory predictive value for the detection of fluid accumulation. Here, however, the authors propose a novel application of impedance monitoring in detecting volume loss events and provide a high PPV by developing a novel impedance classification. It may provoke future studies of improving the PPV of detecting fluid accumulation in a similar fashion. The latest ICD or CRT-D offers considerable information for HF management. Another recent study in the Journal demonstrated that impedance monitoring may predict arrhythmic events, including life-threatening ventricular arrhythmias, in HF patients. We look forward to the authors’ future prospective study validating their results discussed here, which will expand the utility of non-invasive monitoring using implantable devices to deliver better patient care.

References