Parents of teenagers will recognize the following scenario: parent comprehensively lecturing teenager on some topic at hand, carefully outlining the rationale for a parental decision, invoking extensive reasoning of why one option is better than another for good adolescent decision-making, etc, etc. Teenager looks away, rolls eyes (possibly, but not necessarily outside of visual field of parent), and mutters, *sotto voce, “… T.M.I. …”*

**T.M.I. (Too Much Information)?**

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In this issue of *Circulation*, Van Veldhuisen and colleagues report the provocative results of the Diagnostic Outcome Trial in Heart Failure (DOT-HF). They report that providing clinicians with information about intrathoracic fluid accumulation and basing their decision on that information did not lead to the hypothesized improvement in a composite of all-cause mortality or adjudicated HF hospitalizations in patients with chronic HF. In fact, the data suggest that the incremental information was associated with an increase in HF hospitalizations across the follow-up time period. In other words, more information was apparently associated with worse outcomes. How could this be?

DOT-HF enrolled patients with symptomatic chronic HF and systolic dysfunction with at least 1 prior HF hospitalization. The patients were enrolled within 6 months of implantation of a defibrillator or resynchronization device that was equipped with the ability to track intrathoracic impedance. Patients were randomly assigned to a control group, in which neither patients nor their clinicians had access to the impedance data, or to an access group, in which an alert sounded to notify the patient that impedance had fallen below a prespecified threshold, prompting an outpatient visit for assessment and potential adjustment of therapy, which to some degree was protocol-driven. The trial was powered for a 20% reduction in the composite event rate, and the enrollment of 2400 patients was planned, with the expectation of >800 primary composite events. The trial was stopped well ahead of schedule by the sponsor, on the basis of slow recruitment and advances in device technology, which, according to the authors, “… could lead to interpretation difficulties.” At that point, only ≈15% of the planned enrollment had occurred, and enrolled patients were monitored for at least 6 months.

Over an average of 15 months of follow-up, the primary composite end point occurred more often in the access group than in the control group, with a hazard ratio of 1.52 and near statistical significance. This finding was driven by HF hospitalizations, which were increased significantly in the access group, with a hazard ratio of 1.79 (95% confidence interval, 1.08–2.95; *P*=0.022), with relatively similar rates of all-cause death in the 2 groups. The data displayed in Figure 3 of the article suggest that the event curves began to diverge in an unfavorable direction for the access group at 3 to 4 months after randomization.

These unexpectedly negative results prompt thought about how providing information reflecting thoracic fluid accumulation to patients and clinicians, and allowing them to act on it, could lead to an increase in HF hospitalizations and, in fact, all cardiovascular hospitalizations in this trial. Negative results such as these are very important to report and publish, because we then must question all of our assumptions that...
formed the rationale for such an approach. There are several potential explanations.

One possibility is that our assumptions regarding the pathophysiology or mechanism driving an episode of decompensated HF leading to hospitalization are incorrect, or in part incorrect. The use of devices that can provide ongoing readouts of pulmonary artery or left atrial pressures, or those that examine intrathoracic impedance, have suggested that an episode of decompensated HF leading to hospitalization is often preceded by a prolonged subclinical period of a slow increase of pulmonary pressures (suggesting increasing left atrial pressures) or reduction in impedance (suggesting slow accumulation of fluid). These studies led to the enticing possibility that targeting therapy during that subclinical period could reduce the likelihood of clinical decompensation. A close look at the data, however, suggests that the story may be more complex. In the DOT-HF trial, among the episodes of HF hospitalization, only 60% were preceded by an alert condition, where impedance readings fell below the prespecified threshold indicating risk. In other words, the sensitivity of the impedance alert to predict a HF episode was only modest. This is actually consistent with previous studies and false-positives seem common, as well. Published data examining device-determined impedance or pressure measurements tend to report relative risks or hazards associated with an abnormal measurement to predict a subsequent HF episode. The actual discriminatory power may be modest, however. Stevenson and colleagues reported from the Chronicle Offers Management to Patients with Advanced Signs and Symptoms of Heart Failure (COMPASS-HF) trial that the distributions of estimated pulmonary artery diastolic pressures among those patients who did versus those who did not develop HF events showed substantial overlap before the event. Thus, relying on dichotomization of any such signal to trigger treatment is likely to lead to both unnecessary treatment and undertreatment.

Another possibility is that, perhaps, the inclusion of the patient as part of the information loop is an incorrect strategy. In the DOT-HF trial, an alert audible to the patient sounded when an impedance threshold had been crossed, driving a required patient-physician contact for evaluation and possible adjustment of treatment. Could the patient’s knowledge that fluid may be accumulating have influenced the likelihood of HF hospitalization after that visit? The DOT-HF data suggest that almost half of the outpatient visits in the access group were a result solely of an alert, which may have resulted in a drive to more intervention and possibly hospitalization. It is of interest that, in the CardioMEMS Heart Sensor Allows Monitoring of Pressure to Improve Outcomes in NYHA Class III Heart Failure Patients (CHAMPION) trial, in which a wireless implantable hemodynamic monitoring system was used to assess pulmonary pressures, randomization was also to information access or to control (no access) groups, the hemodynamic information in the access group was provided only to clinicians, and patients were blinded, with study design features to optimize masking of patients’ knowledge of whether they were in the access or control groups. In that trial, the clinicians’ access to the data was associated with a significant reduction in HF hospitalizations in comparison with the control group. In the COMPASS-HF trial, the rate of HF events was reduced in the information access group, though the difference did not achieve statistical significance, and a nonprespecified analysis of time-to-event was favorably affected, also in a situation in which the patients were blinded to the information. In the Hemodynamically Guided Home Self-Therapy in Severe Heart Failure Patients (HOMEOSTASIS) trial, left atrial pressure data were made available to patients and clinicians, and an apparently favorable effect on events was reported in a nonrandomized observational study. However, some of the favorable effect may have been associated with increasing doses of angiotensin-converting enzyme inhibitors and β-blockers, as opposed to changes in diuretic or nitrate therapy that one would assume would be most driven by the daily hemodynamic data. A large randomized trial of telemonitoring in which patients reported clinical information daily to potentially trigger a management change showed no beneficial effect on the rate of death or hospital admission for any cause over 6 months. Thus, although we highly value shared decision making with patients in contemporary practice, it is conceivable that incorporating patients into the information-treatment loop was responsible for increasing the likelihood of HF hospitalizations in the DOT-HF trial.

Comparison of the DOT-HF trial with other trials, such as COMPASS-HF or CHAMPION, also suggests the possibility that monitoring and directing treatment at pressure rather than at impedance may be associated with more favorable results. It is also important to note that the DOT-HF trial only enrolled 345 of a planned 2400 patients. Although the confidence intervals around the hazard ratio point estimate of 1.52 for the primary end point excluded the hypothesized 20% reduction in the rate of the primary end point, it is certainly conceivable that a distinct result may have occurred had full enrollment been accomplished. The HF community has seen previous examples in which the results from a small study with provocative findings were found to be incorrect when a larger and more definitive trial was performed.

So what lessons have been learned? DOT-HF joins an instructive group of trials in which unexpected results cause us to question assumptions about the relation between biomarkers and outcomes, and the treatment guided by biomarkers, as well. Suppression of post-myocardial infarction premature ventricular contractions and elevation of high-density lipoprotein levels are examples of strategies that have not worked as planned, despite attractive rationales. In such cases, we are driven to reexamine the mechanistic connection between the marker and the outcome, or to reexamine specific treatment strategies. Much is learned from trials that do not achieve their hypothesized outcome, and it is important that the DOT-HF investigators moved forward with 6-month follow-up of enrolled patients and the publication of their unfavorable results, as well, despite very early termination of recruitment. That decompensation of HF is preceded by a prolonged period of a subclinical slow rise of pressure or slow accumulation of fluid that can be captured by a monitoring device, allowing potential intervention, is highly attractive mechanistically, but it is likely that the story is more
complex, and other mechanisms, such as shifts in central blood volume, may be at play.

The data also highlight the complexity of medical decision making and the role of providing information to drive management. What is the optimal type and amount of information to provide? What treatment algorithm should be applied? What is the role of the patient? Rigorously designed trials testing the effect of information and guided treatment on patient outcomes, as seen in the recent examples cited here, are very important for the community to assess which, if any, of the strategies should be incorporated to benefit our patients. From such trials, we may eventually learn when information may be too much information.

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Dr. Udelson participates on a Steering Committee for a trial of an unrelated device funded by Medtronic.

References

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