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GUEST EDITOR'S PAGE

Connecting Life With Devices

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Medical costs continue to climb exponentially, and 3 of every 4 dollars in the health care budget are now spent on the care of patients with chronic diseases. Concurrent with this is the growing demand for value and a heightened attention to providing patient-centric care. Progressive digitization of the health care industry and electronic health records (EHRs) becoming the norm, are forcibly nudging us to think beyond the predictable pattern of clinical care. There is a huge push in health care to shift the care of our less complex inpatients to the outpatient arena, and the upkeep of our ostensibly clinically straightforward outpatients to in their homes. Much of these care aspirations are hinged on the increased prevalence of wearables and implanted devices, with continuous streaming of physiological data. Simultaneously, there is an impending need for a culture change in our clinical practice, from the conventional care model that is episodic and transactional, to one of continuous care. Even though we see patients at specific time-intervals, disease states don't exactly follow the pattern of our clinic visits. Patients don't fall ill on 3-, 6-, or 12-monthly intervals. Being able to deliver the right care at the right time and at the right place to our patients seems closer to becoming a reality through these advances in the digital world.

The human body has often been equated to the automobile, where many sensors are continuously generating, analyzing, and making decisions off large amounts of digital data. These decisions can be second to second, involving the fine-tuning of an engine or more long term with periodic maintenance check lights indicating the need for an elective check-up. Similarly, every organ system can be monitored via sensors that stream data that are being transmitted on a continual basis. From the cardiovascular organ system perspective; as electrophysiologists, the 2 "big" chronic conditions that we deal with (and that significantly drain the national exchequer in a formidable fashion) include atrial fibrillation (AF) and congestive heart failure. In the world of digital health care, I believe *we may have gotten there first*. We have been implanting devices for the last several decades. These devices, whether they are defibrillators or pacemakers, have imbedded in them a host of simple sensors that derive their information from heart rate, respiration, heart sounds, physical activity, and impedance measures. Many of these variables either individually or combined have the ability to demonstrate rhythm disturbances and predict heart failure decompensation (1). There has been further sophistication of implantable sensors to provide measures of left atrial pressure, pulmonary artery pressure, cardiac output, cardiac contractility, and blood chemistry (2). Recent integrated sensor strategies have the potential to predict heart failure hospitalization up to a month before the seminal event (1). We know that a HF hospitalization event for that matter is an interplay between a susceptible substrate, comorbid states (diabetes, hypertension, AF, chronic obstructive pulmonary disease, etc.), and triggers (ischemia, electrolytes, noncompliance, etc.), thereby emphasizing the need for further upstream-integrated information.

Where do wearable devices fit into this equation? We may still be trying to figure that out in a landscape that continues to get inundated with new devices and apps. Of note, there are already over 350,000 health apps and 350 wearable devices available worldwide. Of these, activity monitors, Fitbits (Fitbit, San Francisco, California) and smart watches, constitute just a small

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percentage of devices that can provide on-the-go medical monitoring. Although most apps were initially wellness apps, there has been a recent increase in apps to monitor disease states. These wearable devices and apps can help us monitor the heart rate, blood pressure, temperature, activity, hydration status, sleep stages, stress, and even blood glucose levels. Although these devices have created a wide range of possibilities, they bring with them several challenges. Most commonly, it is the reproducibility of the measurements, thereby limiting their immediate clinical applicability. A Food and Drug Administration-approved electrocardiogram-monitoring app (AliveCor's Kardia; AliveCor, Mountain View, California) on the other hand, has already begun to have an impact on clinical practice, where patients can self-record their electrocardiogram and help us better manage their AF or other rhythm disorders (3). On a personal note, I have used this successfully to monitor and manage the AF of a few of my patients that spend large periods of time overseas.

Although devices are here to stay and to connect us with the lives of our patients, there are many nuances to this, when we look beyond our anecdotal experiences. While examining the potential of integrating devices into our everyday workflow, we don't need to remind ourselves that there are many hurdles to overcome before some of this becomes clinically valuable. Scaling the use of wearable devices at a macro level across hospitals and the population is beset with many complexities. There are many steps between having a wearable/device and capturing clinically actionable data. Some of these steps include: 1) connectivity of the device with embedded intelligence; 2) appropriate capture and storage of data from the sensors with 3) seamless transport of this data; 4) subsequent integration of the data with the EHR; and 5) availability of appropriate data analytics with artificial intelligence that 6) results in actionable intelligence leading to 7) human value through smart applications or interventions. Unmistakably, there are many interdependent steps, where much can go wrong, without us even beginning to deliberate on the medico-legal, social, ethical, and cyber-security end of things. Notably, user retention of wearables is an issue, and remains quite low. A value-based care model with the appropriate incentives for both the provider and the patient will be critical. The shift in the delivery model from episodic to continuous care will necessarily entail some shift in responsibility to the patient for helping manage his or her own chronic conditions. The principal barrier will be the integration of wearable device data with the EHR, and with that of implantable devices. Which technologies, devices, or vendors will make the cut for EHR integration will need to be determined by rigorous clinical testing and Food and Drug Administration approval.

As electrophysiologists, we seem to be comfortable with the streaming of digital data and remote monitoring of our devices. However, there is already a data deluge coupled with a lack of uniformity of practice across regions, states, and countries. Some of this is dictated by reimbursement, social, cultural, and even legal issues. It is unclear how the wearable device data will fit into this already complex environment. The real shift in the practice paradigm would be not to just increase connectivity, but also to increase accountability at both ends. Empowering patients to self-manage their own disease states by using wearable device data to detect subtle changes, even before they become overtly symptomatic, will be an important goal. Nonetheless, much of this will be dependent on better sensors, more accurate and reliable data, and notably, a transformation in the culture of care.

The future does look quite good. It will become a lot more complex before it becomes exceedingly simple, and during that period, we will continually second guess our choices. There will be a time where the connection of devices with the lives of our patients will be monitored through digital command centers. Data integration supported by deep learning and artificial intelligence will enable risk stratification and focused interventions on the right patient at the right time, in the right place. Life, devices, and digital data will all converge. Nonetheless, it will remain our responsibility to ensure that these technological advances never undermine the humane aspect of medicine.

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