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EDITOR'S FORUM

Subject of the year: remote monitoring

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Implanted cardiac devices have evolved dramatically over the last 50 years from large simple "machines" that could treat only bradycardia to sophisticated "mini-computers" that can be used for the treatment of many different arrhythmias and as an important adjunctive therapy for systolic heart failure, and as a diagnostic option for patients with syncope of uncertain etiology. Remote monitoring of implanted devices, systems now available from all manufacturers, holds promise for extending both depth and breadth of device therapy by enhancing follow-up, providing freer flow of information among multiple caregivers and the patient, and measurement of a wider array of physiologic parameters.

Published single center data suggest that remote monitoring is useful for monitoring patients with implanted devices by more timely identification of potential hardware problems than are routine clinic visits and transtelephone monitoring, and by documenting the presence of important clinical arrhythmias. For example, in one study of patients with implanted defibrillators, remote monitoring identified unsuspected atrial fibrillation in 15% of patients during the first year of follow-up [1]. In another study, remote monitoring identified device system hardware problems such as lead fracture almost a full two months earlier than standard in-person follow-up [2]. Although tantalizing, it should be noted that large prospective trials designed to ascertain the clinical and economic benefit of remote monitoring have not been performed and we are just learning how to integrate remote follow-up data with standard in-person visits and transtelephonic monitoring [3].

Information from remote monitoring resides on databases maintained by individual manufacturers, with web-based interaction by device specialists. Since device information currently also includes important clinical information such as patient activity, indicators of hemodynamic status, and arrhythmia burden, wider dissemination of these data to other clinicians and to the patient is likely to occur in the future. If databases could be coupled to the National ICD Registry, important information on clinical outcomes and earlier identification of actual and potential hardware problems could occur earlier and with greater transparency. An added benefit is direct patient involvement in their own care, which could lead to an important paradigm shift in the delivery of care. As an example, it is easy to imagine a patient with permanent atrial fibrillation titrating their daily dose of AV nodal blocking drugs based on web access to instructions that take average, maximal, and minimal heart rates, along with physician input, into account.

The current generation of implanted devices can store information on heart failure status, including heart rate variability, thoracic impedance, and right ventricular pressure. Thoracic impedance is measured by delivering low amplitude impulses from the right ventricular electrode and measuring impedance at the defibrillator "can." Accumulation of fluid within the lungs is associated with a decrease

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in impedance. Right ventricular pressure is measured directly by an additional stand alone lead with a pressure sensor placed in the right ventricular outflow tract. Devices that can monitor left atrial pressure with a similarly designed lead placed in the interatrial septum are being developed.

ST segment changes can be measured by monitoring baseline deviations after the ventricular signal in far-field electrograms recorded between the SVC coil and the defibrillator "can" and systemic blood pressure appears to correlate with bioimpedance techniques measured from the pectoral muscle [4, 5]. Coupled with remote access, devices that measure these different parameters could potentially be used in the management of a wider variety of chronic diseases. For example, a device originally designed for management of heart failure patients that uses a specially designed pressure sensing lead in the right ventricular outflow tract has been used in patients with pulmonary hypertension [6]. Reduction in pulmonary artery pressure measured by the device correlated with clinical improvement, including an improved six minute walk test. In addition to the active measurement of ongoing parameters mentioned above, an implanted device could be used as a "transmission vehicle" to allow information on past medical and surgical history to be collated on an individual patient database, allowing for a truly portable medical record that could be accessed from any locale with web service.

Remote monitoring of implanted cardiac devices holds great promise for earlier identification of real and potential clinical and device-related problems and thus for earlier physician intervention. This would be expected to improve clinical outcomes and also reduce utilization of healthcare resources, including hospitalizations. Looking to the future, the implications of remote monitoring are far-reaching, with application to a wider array of diseases and facilitating transition to a truly patient-centered model of medical care.

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