# Remote Monitoring
## Technology and Evolving Use

Jane Chen, MD, FHRS

**KEYWORDS**

• Implantable devices • Remote monitors • Atrial arrhythmias • Congestive heart failure
• Lead integrity

**KEY POINTS**

- Remote monitors are transmitters that can download stored diagnostic data from patients' cardiovascular implantable electronic devices to physicians' offices.
- Clinical trials have shown that monitoring implantable devices remotely can lead to earlier detection of clinically relevant events that may result in medical intervention.
- Clinically relevant events that may require action include new-onset atrial arrhythmias, early signs of congestive heart failure, shocks from defibrillators (either appropriate or inappropriate), and compromise in device hardware system.
- Whether early intervention of clinically relevant events using remote monitors can actually lead to a reduction in health care utilization remains inconclusive.

### INTRODUCTION

Since the implantation of the first pacemaker in 1958, cardiovascular implantable electronic devices (CIEDs) have expanded in use and in complexity. The implantation of these devices requires technical expertise for appropriate positioning of leads, avoidance of infection, and tailored programming of the pulse generator. Equally important is the appropriate monitoring of these devices to ensure early detection of device malfunction. Current generations of implantable devices have incorporated extensive monitoring tools that may be used clinically to evaluate patients. In the last decade, remote monitors have been developed by all device manufacturers to download stored information from these devices. These monitors transmit information from patients' homes to physicians' offices, allowing notification of patients' clinical status without additional office visits. This article discusses the utility of these remote monitors in various disease states, their potential impact on health care resources, and possible future benefits.

### TRADITIONAL DEVICE FOLLOW-UP

Pacemakers traditionally were checked from patient's homes via transtelephonic monitoring, which transmitted a snapshot of the heart rhythm and battery status of the pacemaker. In addition, patients were routinely seen in outpatient office visits every 6 to 12 months. Defibrillators did not have transtelephonic monitoring capabilities, and patients were seen in clinic every 3 to 6 months. With the expansion of indications for device implantation over the last 2 decades, these routine device-related office visits have significantly increased outpatient volume. Current devices are also equipped with extensive monitoring capabilities, such as thoracic impedance monitoring for volume overload, onset and duration of atrial arrhythmias, lead integrity alerts, and percentage of pacing. With outpatient follow-up alone, any

Disclosure: The author receives speaker honoraria from Medtronic and St. Jude Medical, and participates in clinic trials with Medtronic, St. Jude, Biotronik, and Boston Scientific.
Cardiovascular Division, Department of Medicine, Washington University School of Medicine, 660 South Euclid Avenue, Campus Box 8086, St Louis, MO 63110, USA
*E-mail address:* janechen@dom.wustl.edu

Card Electrophysiol Clin 6 (2014) 243–251
http://dx.doi.org/10.1016/j.ccep.2014.03.001
1877-9182/14/$ – see front matter 

clinical changes stored in the devices are not usually detected until the following office visit. The current recommendations for routine follow-up of implantable devices are listed in Table 1.[1]

## REMOTE MONITORING BY MANUFACTURER

At present all device manufacturers have created remote monitors for implantable devices, and each has its own unique features (Table 2). Remote monitors are available for all devices, including pacemakers, defibrillators, cardiac resynchronization devices, and implantable loop recorders. Contemporary remote monitors use encrypted radiofrequency signals that allow for transmission and receipt of stored data. Most transmitters require the use of analog phone lines, and data can be uploaded manually or wirelessly to a secure central station where the data are processed. The information is stored on a secure Web site, which is accessible by the patient's following physician and support team. Routine transmissions are usually scheduled by the physician's office. The physician's office can also be notified of any alerts, which are programmable parameters indicating any hardware abnormalities or arrhythmias that may require urgent attention (Box 1).

The Biotronik (Berlin, Germany) Home Monitoring is currently the only truly portable system, as it uses the Global System for Mobile communication (GSM) cellular network system for all transmissions. Therefore, an analog telephone line is not required. Automatic transmissions are uploaded every 24 hours, and any alerts are sent to the physician's office. Routine transmissions may be scheduled by the physician's office, or the accumulated daily collected data may be accessed by the physician at any time for review.

The Boston Scientific (Natick, MA) Latitude system has a unique feature that allows for wireless transmission of blood pressure and weights. In addition, patients can answer a set of questions regarding symptoms, including edema, fatigue, and shortness of breath (Table 3). The blood pressure, weight, and questionnaire answers may be transmitted separately to the patient's general cardiologist, without the additional arrhythmia data.

Medtronic (Minneapolis, MN) CareLink allows a detailed report via the Cardiac Compass visualization system, which shows up to 14 months of accumulated parameters. In addition it shows an OptiVol sensor graph, which illustrates changes in intrathoracic impedance as a potential marker for fluid accumulation and congestive heart failure.

**Table 1**
**Current recommendations for follow-up of implantable devices in person or with remote monitoring**

| | |
|---|---|
| Pacemakers/ICDs/CRT | |
| Within 72 h of CIED implantation | In person |
| 2–12 wk postimplantation | In person |
| Every 3–12 mo pacemaker/CRT-P | In person or remote |
| Every 3–6 mo ICD/CRT-D | In person or remote |
| Annually until battery depletion | In person |
| Every 1–3 mo at signs of battery depletion | In person or remote |
| Implantable loop recorder | |
| Every 1–6 mo depending on patient symptoms and indication | In person or remote |
| Implantable hemodynamic monitor | |
| Every 1–6 mo depending on indication | In person or remote |
| More frequent assessment as clinically indicated | In person or remote |

*Abbreviations:* CIED, cardiovascular implantable electronic device; CRT, cardiac resynchronization therapy; CRT-D, cardiac resynchronization therapy defibrillator; CRT-P, cardiac resynchronization therapy pacemaker; ICD, implantable cardioverter-defibrillator.

*From* Epstein AE, DiMarco JP, Ellenbogen KA, et al. 2012 ACCF/AHA/HRS Focused update incorporated into the ACCF/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities. J Am Coll Cardiol 2013;61:e35.; with permission.

## REMOTE MONITORING TRIALS FOR PACEMAKERS

Current generations of pacemakers are more than just pacing systems, as they have sophisticated monitoring software that can be used for disease management. Remote monitors may assist physicians in more rapidly obtaining these comprehensive data, without the need for more office visits. The Pacemaker REmote Follow-up Evaluation and Review (PREFER) trial[2] was a multicenter, randomized, prospective trial to determine the utility of remote monitoring for the diagnosis of clinically actionable events (CAEs) compared with transtelephonic monitoring (TTM) plus office visits in 897 patients with Medtronic pacemakers. CAEs are defined as events for which a clinical decision may be made and may alter a patient's clinical management (see Box 1). Mean time to detection of any CAE was significantly shorter in the remote group than in the TTM group (5.7 vs 7.7 months). TTM identified only 2% of events, whereas remote