The Modern EP Practice
EHR and Remote Monitoring

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KEYWORDS

• Defibrillators • Patient monitoring • Follow-up • Remote monitoring guidelines

KEY POINTS

- The follow-up of cardiac implantable electronic devices (CIEDs) is transitioning from scheduled routine in-office visits to remote monitoring and alert-driven, unscheduled in-office visits.
- Remote monitoring of wireless CIEDs permits early access to clinically valuable information about system integrity, arrhythmias, and heart failure parameters.
- Clinical trials have substantiated the safety and efficacy of remote monitoring in clinical practice.
- It is imperative that barriers that have limited enrollment of patients into remote monitoring systems and for patients to remotely transmit information on a reliable basis be overcome.
- New work flows have to be developed that facilitate the effective capture and communication of information acquired from remote monitoring systems to ensure maximal clinical benefit for patients.

INTRODUCTION

The implantation of cardiac implantable electronic devices (CIEDs) has increased exponentially during the last decade in response to widening indications. Subsequent monitoring is an integral part of both device and patient care. However, follow-up schedules vary according to facility, physician preference, and available resources.[1] A review of recent US Medicare beneficiaries revealed that almost a quarter of patients were not seen in the year after the implant.[2] This finding represents a quality-of-care deficit, highlighted by the comparative survival advantage gained by those patients who did adhere to the prescribed follow-up.[3] To address this problem, professional organizations have advocated the institution of regular periodic assessments for patients receiving CIEDs.[4] However, frequent in-office evaluation generates a large service commitment and challenges patient compliance, and its efficacy has remained unappraised until recently. Such a system is further stressed in response to product advisories or recalls or with unscheduled encounters (eg, shock therapy or elective replacement indicator [ERI] status). A major limitation of this conventional follow-up method, which is based on patient presentation, is that no monitoring takes place between office visits (ie, most of the time). This lack of monitoring will miss important events, especially if asymptomatic (eg, regarding system integrity or onset of arrhythmias, such as atrial

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fibrillation [AF]). Their early detection is critical to optimal patient care.

Remote Follow-up and Remote Monitoring

Remote monitoring is a potential mechanism for performing intensive device and patient surveillance. Different functions are identified. Remote follow-up involves scheduled automatic device interrogation, which replaces in-office visits aimed at assessing device function (eg, battery status, thresholds, and so forth). The interrogations can be performed automatically in patients implanted with modern wireless devices and manually using wanded home transmitters if the implanted device is not enabled with wireless technology. Remote monitoring involves automatic unscheduled transmission of alert events (eg, AF, abnormal lead impedance, and so forth). This feature is possible in all modern wireless devices. Patient-initiated interrogations are nonscheduled follow-ups initiated manually by patients as a result of a real or perceived clinical event.

Remote Technologies

The platforms available for remote monitoring of CIEDs differ. Wand-based (inductive) systems require patient-driven downloads relayed via telephone connections to tracking facilities.[5,6] These systems are becoming obsolete because they demand coordination with a device clinic on a calendar-based schedule, are cumbersome to use, challenge compliance, and increase service burden without offering gain.[7,8] Important diagnostic data may be overwritten because device diagnostics have finite memory. Early detection is limited. Thus, when used to follow up a pacemaker population, clinically actionable events took several months to be discovered, and only 66% of data were transmitted.[9] In contrast, automatic (wireless or landline) transmission mechanisms are fully independent of patient and physician interaction (**Fig. 1**), which makes them particularly suitable for children[10] and the elderly. Data may be reviewed securely via the Internet. This system was pioneered by Home Monitoring (HM) (Biotronik, Berlin, Germany), with excellent reliability and early notification ability.[11] Ninety percent of transmitted data were received within 5 minutes, with greater than 99% data fidelity. Implantable cardioverter-defibrillator (ICD) generators were shown to self-declare problems promptly regardless of interrogation schedules or associated symptoms.[12,13] System operation is not energy costly.[14] This technology has the ability to maintain surveillance and rapidly bring to attention significant data, enabling clinically appropriate intervention. These potentials have been tested prospectively in recent trials.

Clinical Trials

The first large remote monitoring trial was the Lumos-T Safely Reduces Routine Office Device Follow-up (TRUST).[12,15] In this trial, 1500 patients were randomized to remote management with HM or conventional face-to-face evaluations

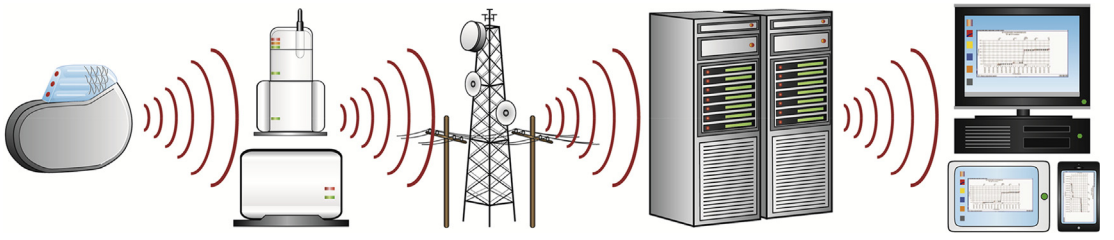

Fig. 1. Automatic remote monitoring technology: transmission steps associated with the Biotronik Home Monitoring system. A very-low-power radiofrequency transmitter circuitry integrated within the pulse generator wirelessly transmits stored data daily to a mobile transceiver (typically placed bedside at night). The data are relayed via landline or wirelessly to a service center that generates customized summaries available online via secure Internet access. Thus, patients are monitored daily, and trend analysis information is compiled from typical follow-up data (eg, battery status, lead impedance, and sensing function). Processing is fully automatic, bypassing potential delays (and errors) associated with manual processing. Critical event data may be transmitted immediately and flagged for attention on the Web page. Automatic alerts occur for silent but potentially dangerous events. These alerts include transmission of intracardiac electrograms (IEGM-online snapshots) similar to those available during office-based device interrogations. This technology provides the ability for early detection and enables prompt clinical intervention, if necessary. Daily transmission load had no effect on battery longevity in the Lumos-T Safely Reduces Routine Office Device Follow-up trial. (*From* Varma N, Ricci RP. Telemedicine and cardiac implants: what is the benefit? Eur Heart J 2012;34:1885–95, with permission; and *Data from* Varma N, Michalski J, Epstein A, TRUST Investigators. Long term preservation of battery longevity (despite daily transmission load) with home monitoring: the TRUST trial. Europace 2013;Suppl:Abstract.)

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