HANDS ON

Enhanced cardiac device management utilizing the random EGM: A neglected feature of remote monitoring

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Introduction

Remote monitoring (RM) of cardiac implantable devices is rapidly becoming the standard of care for implantable cardiac device follow-up.

Several prospective randomized trials have demonstrated the feasibility, safety, and efficacy of remote management and superiority with regard to the early detection of clinical problems as well as maintaining regular scheduled follow-up care.[1–3] This reduced the number of in-person visits while shortening the time to clinical action. Remote management improved patient survival in high-risk patients with heart failure.[4]

To improve the efficiency of remote monitoring, 2 manufacturers (Boston Scientific and Biotronik) launched a new concept in 2006—the transmission of a "randomly" acquired electrogram (EGM). This rEGM displays the endocavitary channels and optionally a "leadless" electrocardiogram (ECG), which is reconstructed between a right ventricular electrode and the can (far-field signal). The goal is to give the physician an opportunity to view a recording similar to one of the 12-lead surface ECGs recorded during any routine in-office visit. By definition, these rEGMs are not supposed to be diagnostic. Since their systematic analysis is time-consuming, they may be neglected. Notably, none of the large randomized trials testing remote monitoring have reported examination of rEGMs, but simply concentrated on alert notifications occurring during remote follow-up.[5,6] On occasion, however, rEGMs provide a unique chance to detect device malfunctions that do not trigger alerts and would otherwise remain undiagnosed. In this article, we present examples of rEGMs that have enabled important medical interventions and describe significant proprietary specifics related to their use.

KEYWORDS Remote Monitoring; Electrogram; Cardiac implantable devices

ABBREVIATIONS **CRT** = cardiac resynchronization therapy; **ECG** = electrocardiogram; **EGM** = electrogram; **ICD** = implantable cardioverter-defibrillator; **RV** = right ventricle/ventricular; **LV** = left ventricle/ventricular; **rEGM** = random electrogram; **RV** = right ventricle/ventricular; **VT** = ventricular tachycardia (Heart Rhythm 2016;13:602–608)

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Characteristics of the periodic EGM according to the manufacturer

The 5 major cardiac device manufacturers have currently included rEGM in their remote monitoring systems (with the exception of subcutaneous implantable cardioverter-defibrillators [ICDs] for which remote monitoring is not yet enabled). rEGMs are either sent regularly (on their own or in combination with a report) or triggered by an alert event or by a transmission initiated by the patient. The transmission scheduled can be nowadays remotely altered via the dedicated Web sites. Depending on the device, the EGM includes 1–4 channels (plus markers) and last 7–30 seconds. Table 1 summarizes the manufacturers' specifics, which are detailed in Online Supplemental Results.

Relevance

We present here different situations revealed by an rEGM that are grouped as sensing issue, capture issue, and arrhythmia detection.

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Table 1 Summary of characteristics of different systems of remote monitoring

Characteristic	Biotronik's Home Monitoring	Boston's Latitude	Medtronic's CareLink	St Jude Medical's Merlin	Sorin's SmartView
Types of transmissions	Scheduled*	Scheduled†Alert triggered Manual (PIT)	Scheduled†Alert triggered Manual (PIT)	Scheduled†Alert triggered Manual (PIT)	Scheduled†Alert triggered Manual (PIT)
Remote programming from the Web site (ICDs)	Yes(since Ilesto Models)	Yes	Yes	Yes	Yes
Duration of EGM (ICDs) (s)	30	30	10	30	7
No. of channels available (+ markers)	Up to 3	Up to 4	Up to 4	Up to 3	Up to 2
EGM filtering	Yes	No	No	No	No
Remark	Automatic changes in pacing mode in PMs		Manual (PIT) is the only option for PMs		Manual (PIT) is the only option for PMs

EGM = electrogram; ICD = implantable cardioverter-defibrillator; PIT = patient-initiated transmission; PM = pacemaker.

*Nominally every 91 d.

†To be defined by the physician.

Sensing issue: oversensing/undersensing

Oversensing

Oversensing may have serious consequences, such as asystole, or inappropriate ICD therapy. Anticipation of these complications is a potential advantage of RM, depending on the ability of the device to recognize and report oversensing. In any case, oversensing needs to be either frequent or sustained to have a chance to be tracked by the device (Figure 1A). Overall, rEGMs represent a helpful tool for the diagnosis of both atrial and ventricular oversensing (Figure 1B). An important role of rEGMs captured by remote monitoring is diagnosis of lead-failure–related oversensing that does not trigger oversensing alerts, especially oversensing related to insulation breaches (Figure 1C).[7]

Undersensing

By definition, undersensing of atrial or ventricular signals remains undetectable for any device: a conventional alert notification will never be triggered for this. However, the condition is important. R-wave underdetection precludes rhythm classification and therapy for life-threatening arrhythmias by the ICD. Diagnosing atrial fibrillation before the first complications occurs (stroke and heart failure decompensation) is a recognized advantage of remote monitoring. Atrial undersensing results in failure to diagnose atrial fibrillation and initiation of anticoagulation, when appropriate. P- or R-wave underdetection causes asynchronous pacing, which may result in atrial or ventricular fibrillation (Figure 2). Of note, P-wave undersensing may precipitate heart failure decompensation in patients with cardiac resynchronization therapy (CRT) in whom it induces a loss of resynchronization. The diagnosis of undersensing remains the responsibility of the caregiver. From that perspective, rEGMs are particularly useful.

Capture issue (Atrial, Right Ventricular, Left Ventricular)

An effective ventricular capture is obviously mandatory for all pacing-dependent patient. A high percentage of biventricular pacing is a prerequisite, and most of the CRT devices are able to warn the cardiologist in case of low CRT rate. At least as important is the percentage of effective left ventricular (LV) capture, which is difficult to evaluate and beat-to-beat automatic control is not available on CRT devices. The search for evidence of LV capture on the rEGM is therefore part of the CRT remote follow-up. This requires having access to the bipolar LV channel and ideally the far-field channel on the rEGM (Figure 3).

Arrhythmia detection

Dual-chamber devices are sensitive to supraventricular tachycardia and report mode switching events as well as sustained episodes. However, atrial fibrillation may be undetected because of the drop off of the atrial signal below the programmed sensing threshold of the device (Figure 4A). VTs are detected above the lower limit of the first VT zone. Below this limit, the device is unaware of any VT episodes, and the rEGM remains the only chance to catch slow VT (Figure 4B).

Discussion

Remote monitoring of cardiac implantable devices allows the early detection of adverse events and significantly lowers the number of ambulatory visits.[8] Current devices are able to automatically detect and transmit lead or battery failure (including lead failure–related noise) and arrhythmias as well as illustrate programming that may be suboptimal in some individuals. However, some diagnoses may require human analysis, especially sensing issues. This may be enabled during remote monitoring by the rEGM, which permits remote detection of cardiac device malfunction. As illustrated above, a large variety of critical situations can be detected with a systematic and careful analysis of rEGMs. Interestingly, all manufacturers provide rEGMs (although under different circumstances) that cannot be disabled. However, their utility has not been reported in any of the major remote monitoring trials.