A missed opportunity for timely intervention to prevent a life-threatening event

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Introduction

The LifeVest wearable cardioverter-defibrillator (WCD; ZOLL Medical Corp, Pittsburgh, PA) has been approved by the US Food and Drug Administration for use with select patients who are at risk for sudden cardiac arrest. However, one of its lesser-emphasized features is the ability to detect asystole and severe bradycardic events that can help in the early identification of patients in need of pacing. Here, we describe the case of a 71-year-old man who had advanced atrioventricular (AV) block lasting 10 seconds documented by the LifeVest system and discuss some of the features of the LifeVest that can be optimized to expedite the care of these patients.

Case report

A 71-year-old man with a history significant for recurrent thromboembolic disease with deep venous thrombosis/pulmonary embolism that was treated with warfarin, dyslipidemia, tobacco use, chronic kidney disease stage II/III, and systemic lupus erythematosus treated with hydroxychloroquine was hospitalized for cardiac surgery for newly diagnosed severe multivessel coronary artery disease and moderate-to-severe mitral regurgitation. The patient's preoperative electrocardiogram (ECG) showed sinus rhythm with first-degree AV conduction delay with a narrow QRS complex of 98 ms (Figure 1A). He subsequently underwent bioprosthetic mitral valve replacement and 4-vessel coronary artery bypass surgery. His postoperative course was complicated by the need for inotropic and balloon pump support for cardiogenic shock with severe biventricular dysfunction and left ventricular ejection fraction (LVEF) reduction to 24% (from 50% prior to surgery). During the postoperative period, he developed nonsustained ventricular tachycardia and atrial fibrillation that was suppressed with amiodarone and lidocaine. Beta-blockers were not initiated owing to right ventricular dysfunction postoperatively. He tolerated amiodarone therapy in the hospital without developing progression of AV conduction delay or block. Given the new drop in LVEF and the need for optimal medical management for 90 days prior to reassessment of LVEF, WCD was recommended. After stabilization, he was discharged to physical rehabilitation with a WCD and oral amiodarone. The ECG on discharge showed sinus rhythm with first-degree AV conduction delay (PR 260 ms), left bundle branch block (QRS duration 158 ms), and left axis deviation (Figure 1B).

Two days after he was discharged from the hospital, while working with a physical therapist, the patient became pale, felt lightheaded, and slumped in the chair, with loss of consciousness for "up to a minute," according to the physical therapy notes. There were no associated symptoms, palpitations, chest pain, or shortness of breath before or after recovery. He was wearing the LifeVest. However, no alerts or LifeVest discharge were noted.

He was seen in the electrophysiology clinic 5 days after discharge from the hospital. LifeVest interrogation showed several episodes of prolonged AV block with P waves marching through, pauses of 6 seconds preceding the event, and a 10-second pause that correlated with the syncopal episode (Figure 2). Additional pauses were also documented with P waves marching through with AV block and ventricular asystole of 4- to 6-second duration with escape ventricular complexes. However, because there were no alerts programmed for asystole or bradycardia, these events were missed until he was seen at outpatient follow-up and rhythm strips were reviewed (Figure 3). He was emergently admitted, and a biventricular implantable cardioverter-defibrillator was implanted. Postprocedure, he has done well over the last 1 year, with no further syncopal episodes.

KEYWORDS Asystole; Bradycardia; Conduction disease; Syncope; Wearable cardioverter-defibrillator

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KEY TEACHING POINTS

- A wearable cardioverter-defibrillator (WCD) has the capability to serve as a continuous cardiac monitoring device for ventricular tachyarrhythmia detection/treatment in high-risk patients within the vulnerable period after acute myocardial injury or revascularization/cardiac surgery and potentially could also monitor for significant pauses in patients with conduction system disease.
- Current criteria for detecting asystole events in patients with WCD will miss a considerable number of patients with significant asystole episodes that do not meet the existing criteria of a fall in electrocardiogram input signal below 100 microvolts for at least 16 seconds.
- Alert features for asystole events need to be turned on, but also required are improvements in WCD design and in the detection algorithms discriminating artifacts and real events. Improved sensing electrode contact with skin would improve the utility of the system to accurately identify long pauses in rhythm in those with underlying conduction system disease.

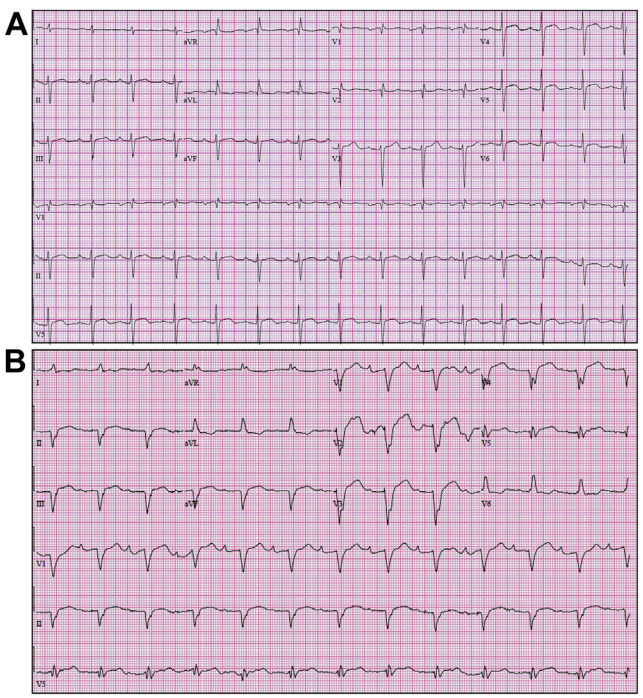

Figure 1 **A**: The preoperative electrocardiogram shows sinus rhythm with first-degree atrioventricular (AV) conduction delay with a narrow QRS complex of 98 ms. **B:** The electrocardiogram on discharge shows sinus rhythm with first-degree AV block, left bundle branch block, and left axis deviation.

Discussion

The LifeVest was approved by the US Food and Drug Administration in 2002 as a wearable defibrillator as well as a continuous cardiac monitoring device. A WCD may be considered for select patients at high risk for sudden cardiac death and is recommended as a class IIb indication in patients with LVEF $\leq$35% who are $<$40 days post acute myocardial infarction or $<$90 days post coronary revascularization, being treated with guideline-directed medical therapy.[1]

This case highlights another possible function of LifeVest that is often underutilized: its capability to serve as a continuous cardiac monitoring device in the vulnerable period after acute myocardial injury or revascularization/cardiac surgery, especially in patients with previous conduction system disease. The default feature of the device is to program for monitoring of ventricular tachyarrhythmias with therapies only for cardioversion or defibrillation of fast ventricular arrhythmias. In most instances, the alert feature of the device for bradyarrhythmias or prolonged pauses is not activated, and therefore, timely attention cannot be paid to these rhythm disorders that can lead to adverse outcomes. Our patient had several pauses lasting 4–6 seconds before syncope, but, owing to the absence of an alert and long default pause threshold, these were missed and were only brought to attention during WCD interrogation at a routine clinic visit. As a default, the WCD criterion to detect asystole is programmed as ECG input signal falling below 100 μV for at least 16 seconds.[2] In the case of asystole, the device is able to instruct bystanders to call an ambulance and initiate cardiopulmonary resuscitation. This feature may potentially shorten the time to cardiopulmonary resuscitation, possibly improving overall survival. However, requiring an asystole event to last for 16 seconds before an alert is sent may result in a significant number of events being missed and hence delay care for patients.

Bradycardia and asystole events in patients prescribed a WCD are uncommon but potentially could lead to significant morbidity after a fall or be fatal. One of the main drawbacks of the current version of the WCD is the absence of backup pacing for bradycardia and asystole events. Device registry data report an incidence of asystole of 0.4%–0.6% while wearing a WCD, with a significantly higher mortality in this patient population.[3] In a study by Chung and colleagues[4] that looked at 3569 patients prescribed a WCD, asystole occurred in 23 patients; of these, 17 died. In the WEAR IT II registry, 0.3% of the 2000 patients had asystole episodes and 3 patients died while wearing a LifeVest, all due to asystole.[5] In a study of 102 consecutive patients with a WCD, out of 157 arrhythmic events, 2 patients had episodes of bradycardia and 5 had asystole.[6] In the VEST trial that evaluated patients with acute myocardial infarction and an LVEF $\leq$35%, a total of 6 patients who died while wearing a WCD had asystole as the terminal event.[7] A total of 41 patients had an alarm indicating an asystole event, but only 6 events were adjudicated as true asystole, suggesting a high rate of false alarms.

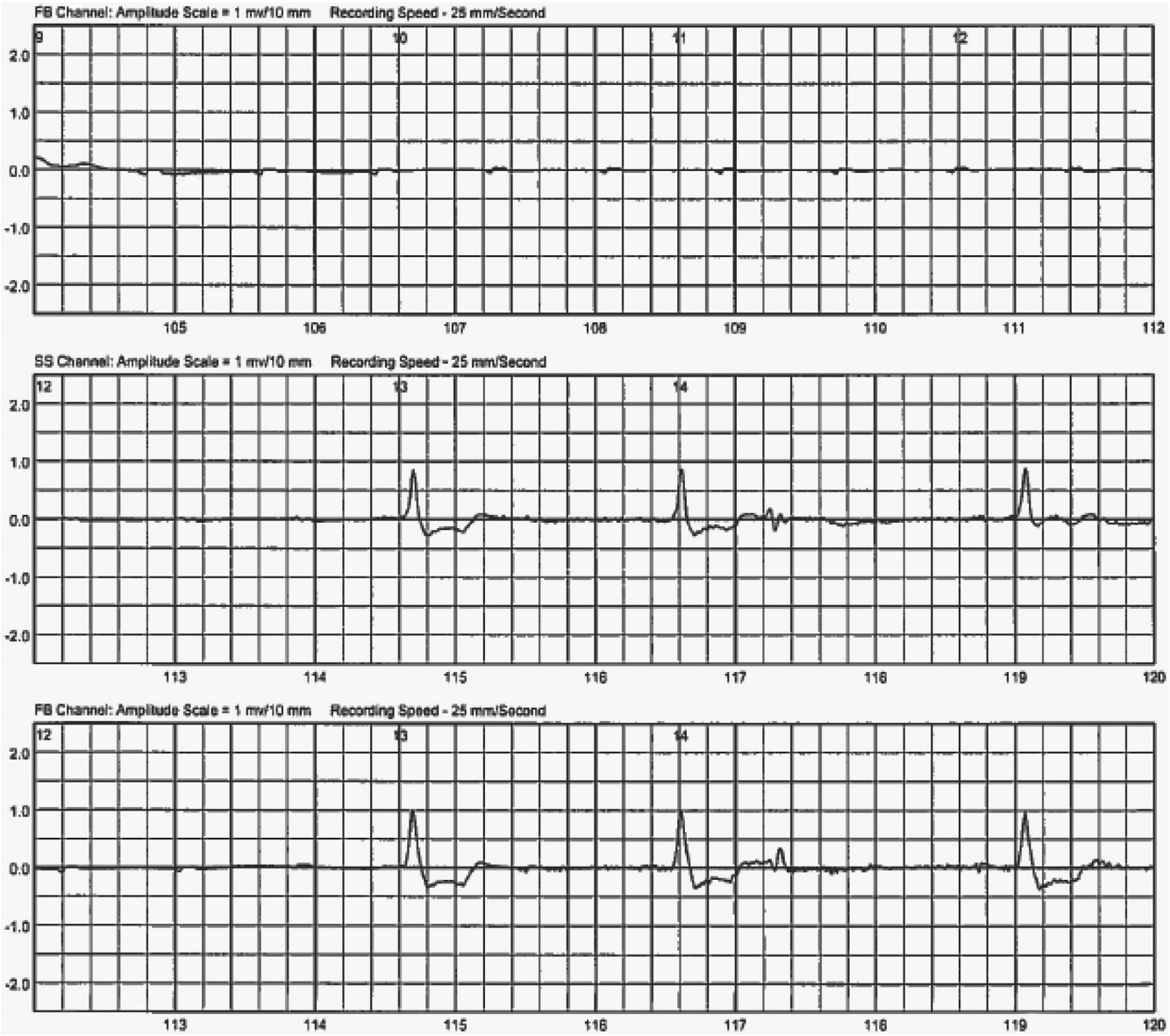

Figure 2 LifeVest wearable cardioverter-defibrillator (ZOLL Medical Corp, Pittsburgh, PA) recording showing a 6-second and a 10-second ventricular asystole event with P waves marching through with complete atrioventricular block.

Although episodes of asystole in this patient population are infrequent, it must be emphasized that patients with coronary artery disease with significant AV conduction delay with bundle branch block are also at risk for the progression of the underlying conduction disease, especially if they have interventions, including valvular surgery or intervention, performed around the conduction system.

Liang and colleagues[8] looked at outcomes after asystole events in patients with a WCD. Out of 51,933 patients who wore a WCD, 257 (0.5%) were noted to have 264 asystole episodes; the overall patient survival rate was 42%. Among patients with serious asystole episodes—defined as those leading to hospitalization, loss of consciousness, or death (201 patients)—survival was extremely poor (26%).

Conclusion

Based on our experience and review of the literature, consideration could be given to the following programming changes for the alerts for bradycardia/asystole events:

(1) The event alert for asystole should be turned on, especially in patients with underlying conduction system disease. Once an event is identified, a notification should be immediately sent to the provider for verification and prompt action.
(2) The current criterion to detect an asystole event by LifeVest is a decrease in ECG input signal below 100 μV for at least 16 seconds. This will miss a significant number of patients who have asystole for <16 seconds. The device programming should be modified to identify pauses of 5 seconds or longer.

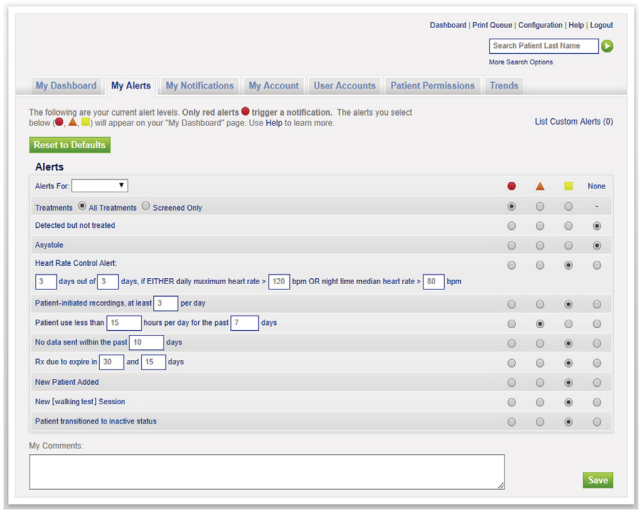

Figure 3 Screen shot of LifeVest (ZOLL Medical Corp, Pittsburgh, PA) alert, which can be programmed to trigger a notification.

(3) Another significant issue is the number of false alarms for asystole. An improvement in the design of sensing electrodes to prevent loss of skin contact will help reduce false alarms. Increasing the number of sensing ECG electrodes (currently 4) to provide more surface ECG leads (currently 2) and correlating the episodes in all ECG leads may help reduce the number of false-positive events.

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