Respiratory rate trending as a cause for atrial lead noise: A first report in an implantable cardioverter-defibrillator patient

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Introduction

During the past 2 decades, awareness regarding the morbidity and possible mortality of device-related recalls and safety advisories has grown. Typically, defects associated with lead fracture or insulation breach are the most severe, necessitating system revision for some patients, whereas other advisories may relate to inappropriate device behavior that may be remedied by device reprogramming. Recently, Boston Scientific issued a voluntary product advisory notice (FDA Class 2 recall notice) regarding intermittent oversensing of the Minute Ventilation (MV) sensor. The advisory was limited to pacemaker systems (ie, Accolade, Essentio, Altrua, or Proponent pacemakers; Valtiude and Visionist cardiac resynchronization therapy–pacemaker devices). We present the first case, to the best of our knowledge, of intermittent lead noise and high impedance associated with the MV due to use of a heart failure diagnostic in an implantable cardioverter-defibrillator (ICD) patient.

Case report

A 76-year-old woman with a past medical history of dilated nonischemic cardiomyopathy, chronic left ventricular systolic failure, supraventricular tachycardia, and polymorphic ventricular tachycardia presented to the clinic with complaints of increasing fatigue, palpitations, and shortness of breath. She had undergone implantation with a Boston Scientific Inogen D142 dual-chamber defibrillator, a St. Jude Tendril 1688TC atrial lead, and a Boston Scientific Endotak Reliance 0293 ventricular lead for primary prevention in January 2016. She had originally done well after implant. Nonsustained supraventricular and ventricular runs were detected by her device, but no therapies were delivered. After implantation, it was noted that her atrial lead impedance had declined from 600 ohms to approximately 450 ohms at 3 months. Ventricular impedance was variable, and overall had climbed slowly, then plateaued. By the end of 2016, her testing remained stable.

In September 2017 she had a routine device check, which showed that the total time in atrial tachycardia / atrial fibrillation was 3.4 hours. Available device electrograms at this point showed true atrial fibrillation (Figure 1) along with intermittent high-frequency noise on the atrial channel (Figure 2). The lead-related noise demonstrated characteristics that seemed to be nonphysiologic, namely uniform amplitude and regular cycle length. This was attributed to electromagnetic interference from an unknown source. Atrial lead impedances were stable. The patient had not been programmed for rate-adaptive pacing (ie, was programmed DDD only), and the heart failure diagnostic was not considered a possible cause at this point.

At her presenting visit in January 2018 she reported fatigue. Her device was interrogated and she was again noted
to demonstrate noise on the atrial lead. In addition, however, were 3 high-impedance measurements between 1200 and 1700 ohms (from baseline of approximately 500 ohms). A decline in atrial sensing (0.8 mV from prior of 3.7 mV) was also noted, but atrial pacing thresholds were stable. During one check, noise could be transiently reproduced with pocket manipulation, and there was concern for possible lead-associated malfunction. There was no evidence of obvious lead fracture on chest radiography. Given the patient’s complaint of worsening fatigue, history of high atrial pacing requirement (>40%), and poor atrial rate histograms, the patient was now programmed to an adaptive mode (DDD-R) to see if this might ameliorate her symptoms while management options were considered for the atrial lead.

The patient reported clinical improvement with rate-adaptive pacing enabled. Given concern for possible lead fracture, a plan was made for atrial lead addition and/or lead extraction. Pacemaker interrogation on the day of the revision revealed additional high-frequency noise episodes. Some of these were longer in duration, and all demonstrated the same morphology as the initial findings. There was clinical suspicion at this point that the MV sensor may have contributed to this abnormality, given that these most frequent noise episodes were identical to that seen previously. It was noted at this time that the patient had previously had the respiratory rate trend heart failure diagnostic enabled when the high-frequency noise events were initially noted. This device diagnostic utilized the MV sensor even when rate-adaptive pacing had not been enabled. The extraction was canceled and the respiratory rate trending diagnostic and the MV sensor were both disabled. The patient returned to the clinic in routine follow-up and no further atrial high rate events or high impedances were noted.

**Discussion**

The major findings of the present report are as follows: (1) Transthoracic impedance measurements using the MV sensor are utilized for heart failure diagnostics—here, the
respiratory rate trend—and may cause intermittent high-frequency artifacts even when rate adaptive pacing is not enabled. (2) The likelihood of MV sensor signal oversensing and presence of the artifact is greater when there is a mismatch between the manufacturer of the can and the lead. (3) The presence of this artifact is not only found in pacemaker patients, as underscored in the safety advisory, but also may present in ICD patients, as was found in our case. In December 2017 Boston Scientific issued a safety advisory regarding intermittent oversensing of the MV signal with pacemaker and cardiac resynchronization therapy—pacemaker systems owing to concern that oversensing might cause presyncope or syncope in pacemaker-dependent patients because of periods of inappropriate pacing inhibition. Specific mention was made that this error was more likely in patients with Medtronic or St. Jude leads. No ICD systems were identified during the communication. Similar to other vendors, Boston Scientific utilizes transthoracic impedance measurements to measure MV. The MV signal is delivered as an 80–320 µAmp, 25 kHz current pulse between the lead and can once every 50 ms (20 Hz). The primary vector is the distal right atrial ring electrode to the device case, while the secondary is the distal right ventricular ring to case. Importantly, the secondary vector is not utilized in the case of ICD patients and therefore the risk of pacing inhibition is unlikely. This discrepancy may be why it was not specifically identified in the advisory communication.

In most instances, the MV sensor signal is filtered by the device, but in situations where a high impedance condition is met, a current imbalance between the ring and can result in a voltage signal in which the MV sensor signal is oversensed by the device. The presence of this artifact has been described previously in the literature in pacemaker patients, first reported in 1988 in early devices and also more recently in contemporary pacing systems. Ryan and colleagues reported that the prevalence of this abnormality was 1.8% in a large series of 959 pacemaker patients. The finding has not been emphasized, however, in ICD patients.

The observation that this artifact is more common in patients with a device–lead vendor mismatch is also notable, and was present in our patient. Differences in the surface finish of leads between manufacturers might cause excess axial or radial motion of the terminal pin when used in a mismatched header, leading to impedance irregularities. Boston Scientific estimated that the probability of injury is 15 times as likely at 5 years when Medtronic or Abbott pacing leads are used in their pacemaker patients. Importantly, the same oversensing artifact may also present in the setting of true lead fracture. As a precaution against this, Boston Scientific devices will evaluate lead connection integrity every hour, and the MV sensor will be suspended should an out-of-range value be encountered. Given the intermittent and stochastic nature of micro-movements within the header, however, this safety measure does not consistently prevent inappropriate sensing.

Conclusion
In both Boston Scientific pacemaker and ICD patients, particularly those in which there is a device–lead mismatch, the respiratory rate trend heart failure diagnostic should be considered in evaluation of those patients who have intermittent high-frequency noise seen on either atrial or ventricular leads and out-of-range impedances that are otherwise unexplained. Disabling this function with subsequent reevaluation of the patient should be considered before undertaking more invasive testing and/or system revision.

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