Intermittent atrial undersensing in patients with single-lead VDD pacemakers is regarded as being of limited clinical significance. Nevertheless, in patients with bradycardia-mediated repolarization abnormalities, undersensing could result in RR-interval oscillations due to changes in pacemaker mode and this could act as a trigger for the initiation of torsades de pointes. We report our findings in 3 patients, which demonstrate the functioning of this trigger mechanism for ventricular arrhythmias.

Key words: Torsades de pointes. Atrial undersensing. VDD pacing. QT-interval prolongation. Complete atrioventricular block.

INTRODUCTION

Pacing with single-lead VDD pacemakers in complete atrioventricular block (CAVB) has been shown to be safe and effective in a number of studies. Atrial undersensing is a disadvantage, but appears to have no relevant clinical repercussions. Nevertheless, the physiopathological changes caused by atrial undersensing can lead to RR oscillations, which may trigger torsade de pointes (TdP) in the context of abnormal repolarization.

We describe 3 patients with a single-lead VDD pacemaker, normal cardiac function, no ion abnormalities, and no intake of QT-prolonging agents. An intermittent atrial sensing malfunction led to bradycardia, sudden RR oscillations, and the appearance of episodes of syncope due to TdP in all 3 patients. The retrospective analysis revealed noticeable QT interval prolongation in the electrocardiograms (ECG) with CAVB. The importance of this finding is discussed.

CASE DESCRIPTIONS

Patient 1

An 81-year-old woman had received a single-lead VDD pacemaker (Vitatron Saphir 3) for CAVB; sinus rhythm at 90 bpm was recorded prior
Patient 1

A 72-year-old man, who had received a VDD pacemaker with tachyarrhythmia capture (Medtronic EnPulse) 15 days earlier for CAVB, presented loss of consciousness with no pulse and was resuscitated by cardiopulmonary resuscitation. The device stored a tachyarrhythmia with variable cycle lengths and morphologies consistent with polymorphic tachycardia (Figure 2A). Pacemaker interrogation showed frequent runs of presyncopal polymorphic tachycardia related to loss of atrial sensing (despite sensitivity set to minimum) and pacemaker switch to VVI mode at the lower pacing limit. Emergency VVI programming at a high pacing rate was required. In addition, at a pacing rate of 60 bpm in this mode, QT intervals of 600 ms were of particular interest (Figure 2B). A 2-chamber implantable cardioverter defibrillator (ICD) with a lower rate limit, programmed at 50 bpm, was ultimately implanted. Over the course of the next 3 years, intrinsic atrial and ventricular rhythm predominated, and no new ventricular arrhythmias were observed. A retrospective analysis of the ECG that led to implantation of the VDD pacemaker showed extremely prolonged QT intervals for the heart rate, with absolute QT values of 620 ms and corrected QT interval (QTc, Bazett formula) of 525 ms (Figure 1D).

Patient 2

A 78-year-old woman, who had received a VDD pacemaker with tachyarrhythmia capture (Medtronic EnPulse) 15 days earlier for CAVB, presented loss of consciousness with no pulse and was resuscitated by cardiopulmonary resuscitation. The device stored a tachyarrhythmia with variable cycle lengths and morphologies consistent with polymorphic tachycardia (Figure 2A). Pacemaker interrogation showed frequent runs of presyncopal polymorphic tachycardia related to loss of atrial sensing (despite sensitivity set to minimum) and pacemaker switch to VVI mode at the lower pacing limit. Emergency VVI programming at a high pacing rate was required. In addition, at a pacing rate of 60 bpm in this mode, QT intervals of 600 ms were of particular interest (Figure 2B). A 2-chamber implantable cardioverter defibrillator (ICD) with a lower rate limit, programmed at 50 bpm, was ultimately implanted. Over the course of the next 3 years, intrinsic atrial and ventricular rhythm predominated, and no new ventricular arrhythmias were observed. A retrospective analysis of the ECG that led to implantation of the VDD pacemaker showed extremely prolonged QT intervals for the heart rate, with absolute QT values of 620 ms and corrected QT interval (QTc, Bazett formula) of 525 ms (Figure 1D).
DISCUSSION

Although the QT is physiologically prolonged in bradycardia, TdP rarely appears. Onset of TdP has been described, however, in 5% to 30% of patients with CAVB. In this regard, Kurita et al observed that patients with CAVB who developed TdP had abnormally prolonged QT intervals at lower heart rates.

It is not entirely clear why noticeably prolonged repolarization occurs in some patients with bradycardia.
Chevalier et al^4 studied the hypothesis of latent genetic alterations and analyzed the genetic prevalence of mutations among the subgroup of patients with CAVB and QT ≥600 ms; these authors found mutations in only 17% of cases. Various limitations described in the study may explain the low prevalence observed. One limitation that is impossible to ignore is the time dependence of the QT interval, namely, that the duration of the CAVB itself noticeably prolongs the QT interval.\(^5\)

Of note, QT intervals measured in ECGs with CAVB from the 3 patients described showed an absolute value of ≥600 ms in the absence of drugs and ionic abnormalities. Furthermore, time-dependent shortening of the QT interval was documented in patient 1 after VVI pacing at 70 bpm, which shows the importance of time in repolarization remodeling. Therefore, according to the repolarization concept described by Roden et al,\(^6\) it is likely that these patients carry a mutation of genes that regulate ventricular repolarization, which has remained subclinical because it is compensated by other ionic currents and only manifests as QT prolongation and onset of TdP under certain stressful conditions (such as the bradycardia in our 3 patients), favored by loss of atrial sensing.

Although a direct relationship between short-long-short sequences and TdP onset was not observed in patients 2 and 3, we believe that RR oscillations must have played a key role. Given the probable predisposition to the onset of TdP in these patients with bradycardia, it is noteworthy that polymorphic tachycardia did not occur during the CAVG episode. In this regard, we believe that bradycardia, which was a result of setting the lower rate to the lowest limit, as well as RR interval irregularity, a result of intermittent atrial undersensing and pacing hysteresis, may have combined to reduce the repolarization reserve and, consequently, lead to TdP.

We believe that the lack of previous descriptions of the problem described in this report may be due to the fact that, along with the low incidence of undersensing,\(^7\) a number of conditioning factors must come into play to produce TdP (probable genetic substrate, duration of bradycardia, lower pacing limit programmed, female sex, and other unknown factors).

The QT interval limit at which a patient with CAVB should be considered potentially predisposed to the events described is unknown. Nevertheless, according to the literature, an absolute QT ≥600 ms or a Tpeak-Tend>85 ms,\(^8\) should raise concern about whether the patient has bradycardia-sensitive repolarization, particularly if the QT continues to be abnormally long with VVI pacing at a normal heart rate of 70 bpm. In this case, good atrial sensing should be attempted in the implant if a VDD system is chosen. The presence of T-wave notches similar to long QT syndrome type II could indicate a risk of TdP.\(^8\)

In conclusion, before considering defibrillator implantation in patients with a VDD pacemaker who present polymorphic arrhythmias and proven atrial undersensing, the effect of arrhythmogenic drugs, ionic abnormalities, and ventricular dysfunction should first be ruled out. The mechanism presented should then be considered, with careful review of the QT interval of the CAVB episode and QT at slow pacing frequencies. Once the mechanism is identified, slow pacing frequencies should be avoided, and pacemaker hysteresis should not be programmed. These measurements will typically minimize loss of atrial sensing. However, if it is not possible to minimize the detection failure, it may be necessary to implant an atrial lead.

REFERENCES