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Journal of Electrocardiology 46 (2013) 136 – 139
JOURNAL OF Electrocardiology
www.jecgonline.com

Automatic mode switching of a dual chamber implantable cardioverter–defibrillator induced by a ventricular escape rhythm

S. Serge Barold, MD,[a,*] Frederic Van Heuverswyn, MD,[b] Roland X. Stroobandt, MD, PhD[b]

[a]*Florida Heart Rhythm Institute, Tampa, Florida, USA*

[b]*Heart Center, Department of Electrophysiology, University Hospital Ghent, Ghent, Belgium*

Abstract

This report describes a form of group beating induced by a St Jude dual chamber ICD which interpreted a ventricular escape rhythm (with retrograde conduction) as premature ventricular complexes (PVC). These pacemaker-defined PVCs activated the atrial pace-PVC algorithm in 2 steps. 1. The postventricular atrial refractory period (PVARP) was terminated upon detecting a retrograde P wave within its unblanked portion, and 2. An atrial stimulus was released 330 ms after the end of the PVARP. This response resulted in automatic mode switching because the 330 ms interatrial interval was shorter than the atrial tachycardia detection interval.

The arrhythmia may be considered to represent an unusual form of pacemaker escape–capture bigeminy.

Keywords: Implanted cardioverter–defibrillator; Pacemaker; Automatic mode switching; Premature ventricular complexes; Ventricular escape rhythm; Escape–capture bigeminy

Introduction

This report describes a form of group beating induced by a St Jude dual chamber ICD (St Jude Medical, Sylmar CA) which interpreted a ventricular escape rhythm as pacemaker-defined premature ventricular complexes (PVC). The response of the device to the ventricular escape rhythm activated the automatic mode switching algorithm.

Case report

A St Jude AnalyST Accel ICD (St Jude Medical, Sylmar, CA) had been implanted in a 72 year-old man with sick sinus syndrome and markedly depressed left ventricular systolic function 15 months before the arrhythmia in Figs. 1 and 2 was recorded. No previous episodes had occurred. Table 1 outlines the ICD parameters. Fig. 1 which was retrieved from the stored memory of the device (at a time when the patient was asymptomatic), shows group beating with recurring sequences of a ventricular escape beat followed by an AP–VP delay (AP = atrial paced event, VP = ventricular paced event). Each ventricular escape beat was sensed (VS) and interpreted by the device as a premature ventricular complex (PVC) thereby activating the atrial pace-PVC algorithm. VS events were associated with retrograde ventriculoatrial conduction which the device detected in the postventricular atrial refractory period (PVARP) shown as a short upward vertical line in the marker channel without symbolic assignment. The device aborted the PVARP upon detection of the retrograde P wave and then released AP (followed by VP) 330 ms after the retrograde P wave. Fig. 2 was recorded after a brief unstable ventricular rhythm when the ECG settled into regular ventricular pacing at the automatic mode switching (AMS) base rate of 70 ppm. This gave rise to retrograde ventriculoatrial conduction shown by an "AS" marker (in contrast to Fig. 1) because during AMS the device functions in the DDI mode without a PVARP retaining only the postventricular atrial blanking period. The atrial-pace-PVC response was turned off and the arrhythmia in Figs. 1 and 2 has not recurred over a follow-up of 15 months.

Discussion

Response to premature ventricular complexes

The atrial pace-PVC response of St Jude devices is a programmable function that detects and responds to pacemaker-defined PVCs in the DDD(R) and VDD(R) mode for pacemakers and the DDD(R) for ICDs.[1,2] The

* Corresponding author. Tel.: +1 813 891 1922.
E-mail address: ssbarold@aol.com

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http://dx.doi.org/10.1016/j.jelectrocard.2012.12.001

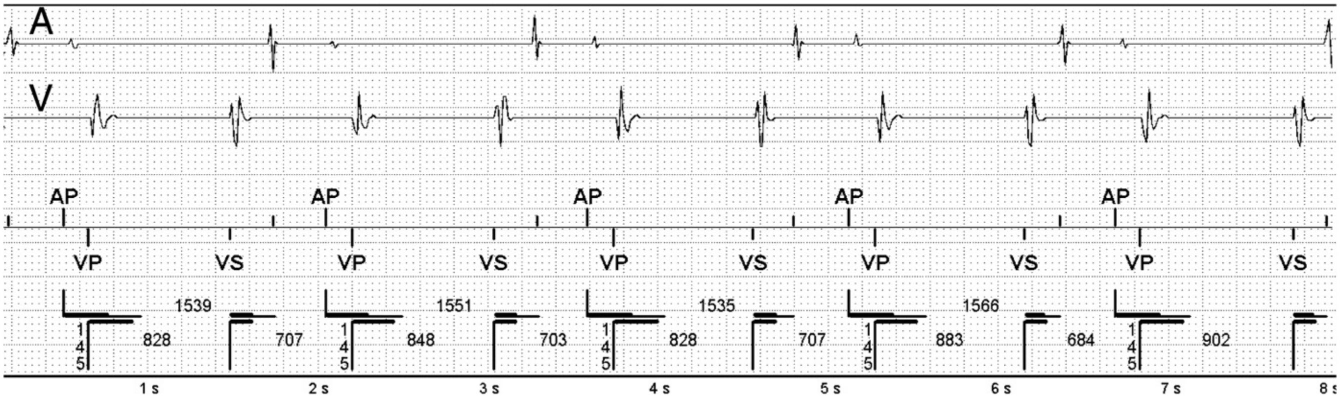

Fig. 1. Stored recordings of a ventricular escape rhythm interpreted as ventricular premature complexes (PVC) by the atrial-pace PVC algorithm of a St. Jude ICD (PVC = premature ventricular complex). The atrial electrogram (A) and the ventricular electrogram (V) are on top. The marker channel is in the middle and the marker depicting the blanking/refractory intervals is at the bottom. The horizontal lines correspond with the duration of the blanking and refractory periods: the atrial intervals are above the ventricular intervals. The thicker lines show the atrial and ventricular blanking periods. The postventricular atrial refractory period (PVARP) is represented by the thin line beyond the postventricular atrial blanking period (thick line). PVC = premature ventricular complex, AP = atrial paced event, VS = ventricular sensed event, VP = ventricular paced event. See text for details.

atrial pace-PVC response occurs if a sensed R wave (VS) is not preceded by an atrial event (as in this case) or if a P wave (AR) is detected in the unblanked portion of the postventricular atrial refractory period (PVARP) provided it is not followed by an R wave within 280 ms of the atrial event. The atrial pace-PVC response consists of two steps. In the first step the PVARP lengthens to 475 ms for one cycle (in contemporary devices and 480 ms in older devices) but the PVARP is aborted immediately upon detection of an atrial event within the PVARP. Fig. 1 shows how the ventricular escape beats gave rise to retrograde conduction with a ventriculoatrial (VA) interval of 240–260 ms resulting in PVARP shortening equal to the retrograde VA conduction interval. Then, in a second step the device releases an atrial stimulus (AP) 330 ms (nonprogrammable duration) after the end of the PVARP. In this case AP is clearly connected to the atrial pace-PVC algorithm because no other timing cycle can deliver an AP event at this particular time. The AP which is part of the atrial pace-PVC algorithm is followed by a VP event according to the programmed AV delay. In the atrial pace-PVC algorithm, AP will be inhibited if a P wave or R wave is detected within the 330 ms period related to the atrial pace-PVC algorithm. The 330 ms interval is usually sufficient for the atrial myocardium to emerge from its myocardial refractoriness. The atrial stimulus renders the atrial tissue refractory to a possible subsequent relatively early event associated with retrograde VA conduction (although the efficacy of this kind of atrial stimulation is unknown). The bigeminal sequence eventually activated the automatic mode switching (AMS) function (Fig. 2).

Automatic mode switching algorithm

The AMS algorithm in St Jude's devices uses a "running average" rate (also known as the mean atrial rate, filtered or matched atrial rate).[2,3] The device moves towards AMS by continuously monitoring the spontaneous atrial interval and generating a filtered heart rate interval (FARI) that changes according to the duration of the prevailing sensed atrial cycle. AMS will occur when the FARI shortens to a predetermined duration equal to atrial tachycardia detection interval. Because the process is gradual, the rapidity of reaching AMS will depend not only on the atrial tachycardia detection interval, but also on the pre-existing atrial rate almost always the sinus rate. The FARI reaches the atrial tachycardia detection interval faster when atrial tachycardia

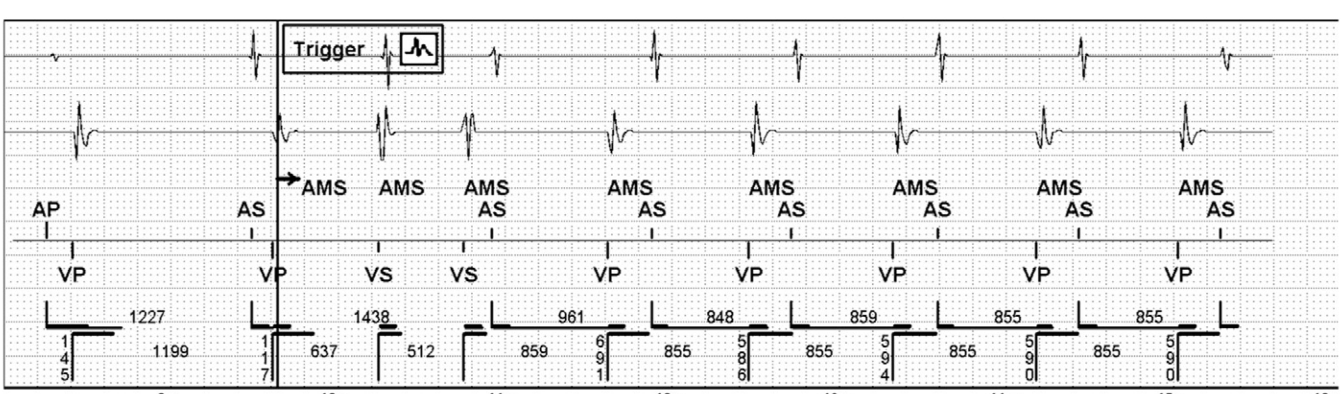

Fig. 2. Automatic mode switching (AMS) shown in a stored recording with same arrangement as in Fig. 1. The tracing is continuous with Fig. 1. AS = atrial sensed. See text for detail.