Undersensing of ventricular fibrillation due to interference between a pacemaker and defibrillator in the same patient

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Sensing in pacemakers (PMs) and implantable cardioverter defibrillators (ICDs) is crucial to normal device behaviour. Since both devices treat different arrhythmias, the technical approach to signal detection is also completely different. A PM has a fixed threshold of sensing, above which events are sensed and therapy of the device withheld. On the other hand, the defibrillator has a variable threshold of sensing to detect tachyarrhythmias, with sometimes very small and changing electrogram amplitudes. In this case report, we describe interference between a PM and an ICD caused by these differences in the detection of cardiac events, leading to undersensing of ventricular fibrillation at defibrillation threshold testing.

Case

We present a 37-year-old male with congenital Tetralogy of Fallot, surgically corrected at the age of 7 after a prior Waterston anastomosis at 3 years of age. At the age of 18 years, he received a pre-pectoral, single-chamber pacemaker (PM) with an endovascular placed right ventricular unipolar lead because of third-degree atrioventricular block.

He was admitted with repetitive runs of ventricular tachycardia, which were haemodynamically not tolerated. He was sedated and ventilated, and stable sinus rhythm was restored after intravenous administration of amiodarone and beta-blockade. Since there was no underlying ischaemic or metabolic problem, we opted for implantation of a dual-chamber implantable cardioverter defibrillator (ICD) in secondary prevention (class IB indication ACC/AHA/HRS guidelines 2008).

In view of the fact that he was PM-dependent and had no underlying escape rhythm, his PM (Medtronic Kappa SR) was left in place during the procedure. The implantation of the ICD (Medtronic Virtuoso DR) was carried out under general anaesthesia. The implantation of the atrial (Medtronic 5076-S2) and ventricular lead (Biotronik Linox S65) was uneventful. At a second position, both sensing and pacing thresholds were acceptable (atrial 1.7 mV, 0.6 V at 0.5 ms; ventricular 0.6 V at 0.5 ms). At the end of the procedure, combined upper limit of vulnerability/defibrillation threshold (ULV/DFT) testing was performed to ensure safe defibrillation of ventricular tachyarrhythmias. Ventricular fibrillation (VF) was induced with a 4 J shock on T with a coupling interval of 390 ms after a pacing train of 8 beats at a cycle length of 500 ms. The initial electrograms during VF were large (>7 mV) and detection by the ICD is normal. After binning 12 in 16 ventricular events in the VF zone (FS, VF sense), VF is detected and the capacitors of the ICD are charged. After charging, however, there is no confirmation of the tachycardia (four of five events have to be seen within a window of 320 ± 60 ms) and therapy is aborted. Undersensing continues to be a problem with only sporadic detection of fast ventricular events. Finally, redetection criteria are met (six of nine FS) and the first VF therapy (a 20 J shock) is delivered committed, synchronized to the second sensed event (cardioversion/defibrillation pulse). However, this shock was not successful in terminating VF. Fortunately, the tachycardia spontaneously terminates a few beats later (Figure 1). Also a second 24 J shock was not successful and in order to obtain a better DFT, we implanted a subcutaneous lead array. Subsequent ICD testing was successful in delivering an appropriate shock, with a DFT <20 J.

The cause of undersensing by the ICD was the spikes delivered by the VVI-PM pacing at 60 bpm. There is undersensing of VF by the PM leading to inappropriate pacing at the programmed rate. The pacing spikes are sensed by the ICD and repeatedly reset the dynamic sensing threshold leading to undersensing of VF by the ICD as soon as the electrograms during the arrhythmia become smaller and start changing polarity.

In a second procedure, the interfering device was removed. Up till now, all ICD follow-up consultations revealed a normal functioning. No tachycardia episodes were seen with delayed of withheld therapy after the explantation of the VVI-PM.

Discussion

The programmed sensitivity in a PM or an ICD defines the minimum electrical amplitude recognized by the device as an intrinsic atrial or ventricular sensed event.

All current PMs have a stable sensing threshold. ICDs, on the other hand, have a variable sensitivity during the cardiac cycle. Since their main target is the recognition of tachyarrhythmias, a very sensitive setting is necessary. However, to prevent inappropriate therapy, triggered by extracardiac signals or T-wave oversensing, too sensitive settings should be avoided. Therefore, the ICD resets its sensitivity threshold after a sensed event to a percentage of the amplitude of this sensed electrogram and then progressively

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lowers this threshold (making the device more sensitive). With these kinds of algorithms, ICDs can sense events even if they are very small and have beat-to-beat variations in amplitude.  

In our case, this ICD algorithm is misled by PM spikes, delivered by the PM. This leads to temporary undersensing of VF, leading to a delay of therapy. As an implanting physician, it is necessary to understand this phenomenon and to be aware of it in case of necessity of (temporary) pacing during implantation of an ICD.

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References