INNOVATIVE TECHNIQUES

COMPLEX CASE STUDY

Tachycardia Detected by Devices: What is the Mechanism?

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ABSTRACT. Using a case of supraventricular tachycardia (SVT) that occurred during pacemaker implantation we discuss a schematic way to identify arrhythmias observed during “failed” antitachycardia pacing in implantable cardioverter-defibrillators.

KEYWORDS. antitachycardia pacing, implantable cardioverter-defibrillator, tachycardia.

Case presentation

A 72-year-old woman, with a history of ischemic heart disease, hypertension, and diabetes was admitted to our institution with breathlessness and presyncopal events. Routine 12-lead electrocardiogram (ECG) showed sinus arrest with a narrow complex escape rhythm at 40 bpm. A dual-chamber pacemaker was inserted: a 3830 lead (Medtronic, St. Paul, MN) to the mid-right ventricular (RV) septum and a 5076 lead (Medtronic) to the right atrial appendage (RAA) were attached to the pulse generator (Adapta ADDRL 1, Medtronic) dual-chamber device. A narrow complex tachycardia was induced by atrial pacing while attempting to check the lead threshold at implantation. Ventricular overdrive pacing (VOP) was performed during this tachycardia to aid differentiation of the tachycardia mechanism (Figure 1). In Figure 1a the tachycardia continued, whereas in Figure 1b the tachycardia transiently stopped but was immediately reinitiated. What is the mechanism?

Comment

During the tachycardia, VOP performed via the RV septal lead accelerated the atrium to the same pacing cycle. The tachycardia continues after this maneuver and so we can use the post-pacing parameters as would be used in a standard electrophysiology study.1

The first such parameter is the post-pacing interval (PPI), defined as the interval between the last pacing stimulus and the next recorded activation in that same electrode. In standard EP practice a short PPI represents a recording within the re-entrant circuit whereas a long PPI indicates the electrode is far away from the circuit. As shown in Figure 2, in this case the absolute PPI was long at 680 ms, suggesting the lead tip is remote to the tachycardia circuit. In fact, so far out that it is probably not in the same chamber. Work done by Michael et al2 suggests that in this context an absolute PPI greater than 615 ms suggests an atrial rather than a ventricular arrhythmia. Looking at episodes of failed antitachycardia pacing (ATP) delivered by implantable cardiac defibrillators (ICDs), Michael et al2 showed that atrial arrhythmias had an absolute PPI of 693 ± 96 ms compared with 582 ± 83 ms for ventricular arrhythmias. Using a cut-off of 615 ms had a positive predictive value of 78%.

Having distinguished the origin of the tachycardia as atrial rather than ventricular, the next parameter that can be used is the return sequence after pacing termination. If this shows an activation sequence of ventricles, then atria, then ventricles (VAV), work by Knight et al1 indicates that a VAV response is more suggestive of a re-entrant arrhythmia (Atrioventricular nodal reentrant tachycardia (AVNRT) or atrioventricular reentrant tachycardia (AVRT)), whereas a pattern activation of ventricle–atria–atria–ventricle (VAAV) is more suggestive of automatic atrial tachycardia. A further observation is that if the tachycardia terminates in the atrium, as...
Figure 1: Recording from pacing analyzer (2090, Medtronic) showing lead II surface electrocardiogram, marker channel, and atrial intracardiac electrogram from lead in right atrial appendage. In both (a) and (b) there is entrainment of the atria with overdrive pacing from the right ventricular lead implanted at the mid right ventricular septum. (a) The arrhythmia continues. (b) The arrhythmia briefly terminates to be recommenced by an atrial ectopic. VP: ventricular paced event; VS: ventricular sensed event; AS: atrial sensed event.

Figure 2: Annotated versions of Figure 1a. (a) Post-atrial entrainment the absolute post pacing interval (PPI) is greater than 615 ms, the post-pacing interval – tachycardia cycle length (PPI – TCL) is greater than 115 ms and there is a VAV response. (b) The interval between ventricular paced event (Vp) to atrial sensed event (As) minus the interval between ventricular sensed event (Vs) to atrial sensed event is greater than 85 ms. These features together suggest a re-entrant supraventricular arrhythmia involving the AV node, most likely AVNRT. PCL: pacing cycle length; TCL: tachycardia cycle length.
in Figure 1b, it is more likely to be re-entrant rhythm involving the AV node, where transient blockade of the node acts to terminate the tachycardia.

In a patient with a VAV response we next move onto the third set of parameters to help to distinguish AVNRT from AVRT.3 Both of these look at the tachyarrhythmia response to the overdrive pacing (Figure 2a). Figure 2a shows PPI – TCL: this measurement looks at the difference between the PPI and the interval between activations during the ongoing tachycardia i.e. the tachycardia cycle length (TCL). A difference (PPI – TCL) <115 ms suggests a septal pathway and AVRT, whereas measurements greater than that indicate AVNRT is more probable. Figure 2b shows VpAs – VsAs: this measurement looks at the difference between the time it takes the activation to travel from the ventricle to the atrium in the very last paced beat (VpAs) compared with a sensed beat during the tachycardia (VsAs). A difference (VpAs – VsAs) <85 ms suggests the rhythm is more likely to be AVRT, whereas values greater than 85 ms are more often found in AVNRT. The caveat to this is a left lateral pathway where the retrograde conduction to the pathway takes a long time from the right ventricular pacing site. In the case here, PPI – TCL =160 ms and VpAs – VsAs =100 ms support the diagnosis of AVNRT.

Tachycardia at pacemaker implantation is exceedingly rare, as is the incidental discovery of SVT at routine pacemaker follow-up. Rather more common is “failed” ATP from ICDs. Here the device delivers a salvo of 8 beats at a rate faster than the tachycardia. If such trains manage to accelerate the atria to the same cycle length without terminating the tachycardia, then 1) an absolute PPI >615 ms suggests an atrial rather than a ventricular source;2 2) VAV versus VAAV response helps to differentiate re-entry from automatic atrial tachycardia1,4 and 3) PPI – TCL and VpAs – VsAs can help to further differentiate between re-entry mechanisms (Figure 3).

Figure 3: Steps to differentiate the tachycardic mechanism after “failed” antitachycardia pacing delivered by an implantable cardioverter-defibrillator.

References
2. Michael KA, Haley C, Baranchuk AM, et al. The post-pacing interval following failed antitachycardic pacing can be used to differentiate between atrial and ventricular tachycardias in ICDs. *Heart Rhythm* 2011; 8: S114.
