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# ICD discrimination of SVT versus VT with 1:1 V-A conduction: A review of the literature

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ABSTRACT

Inappropriate ICD shocks are associated with increased mortality. They also impair patients' quality of life, increase hospitalizations, and raise health-care costs. Nearly 80% of inappropriate ICD shocks are caused by supraventricular tachycardia. Here we report the case of a patient who received a single-lead dual-chamber sensing ICD for primary prevention of sudden cardiac death and experienced inappropriate ICD shocks. V-A time, electrogram morphology, and response to antitachycardia pacing suggested atrioventricular nodal reentry tachycardia, which was confirmed in an electrophysiology study. Inspired by this case, we performed a literature review to discuss mechanisms for discrimination of supraventricular tachycardia with 1:1 A:V relationship from ventricular tachycardia with 1:1 retrograde conduction.



## Contents



## Introduction

Implantable cardioverter defibrillator (ICD) use has been shown to reduce mortality among patients with heart failure and left ventricular systolic dysfunction [1–6]. However, up to 13% of patients who receive an ICD can receive inappropriate shocks and as much as 31% of total shocks delivered by ICDs are considered inappropriate [7,8]. Nearly 80% of inappropriate ICD shocks are caused by supraventricular tachycardia (SVT), which includes atrial fibrillation (AF), atrial flutter,

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sinus tachycardia, atrial tachycardia, atrioventricular (AV) reentrant tachycardia, and AV nodal reentrant tachycardia (AVNRT) [8]. AF is known to be a common cause of ICD therapies, but the rhythm irregularity and other factors facilitate fairly accurate discrimination and avoidance of ICD shocks via device programming [8–10]. At the same time, all SVT entities with the exception of AF can exist with a 1:1 A-V relationship, thereby presenting a potential diagnostic challenge.

Discrimination of ventricular tachycardia (VT) from such arrhythmias is believed to be facilitated by the presence of dual-chamber detection [11,12]. However, the Centers for Medicare & Medicaid Services does not reimburse the addition of an atrial lead for that purpose alone in patients who have no documented SVT prior to device implantation [13], because there is evidence that SVT-induced ICD shocks can be avoided just as successfully with a single lead device and optimal device programming [14–16]. Furthermore, implanting an atrial lead solely for that purpose adds unnecessary risk to the procedure, particularly dislodgement, perforation, and vascular injury [17–19].

It is in that context that the FDA recently approved a novel ICD lead that enables two-chamber sensing without requiring a separate atrial lead [20]. Herein we present a patient who received an ICD using such a lead but nevertheless experienced inappropriate ICD shocks secondary to SVT, consistent with typical slow-fast AVNRT. This case inspired a literature review of the discrimination mechanisms designed to differentiate SVT with a 1:1 relationship from ventricular tachycardia (VT) with 1:1 retrograde conduction.

## Case report

A 57-year-old man with non-ischemic dilated cardiomyopathy and an ejection fraction of 20% for several years despite optimal medical management received an ICD for primary prevention of sudden cardiac death. The implanted device employed a single lead with atrial sensing capabilities (BIOTRONIK Lumax 740 VR-T DX, BIOTRONIK SE & Co KG, Berlin, Germany). Of note, although he had experienced palpitations in the past, at the time of device implantation he had no documented history of tachyarrhythmias. Several months after the implant, he presented to the electrophysiology clinic with recurrent ICD shocks. The patient reported multiple episodes of palpitations and lightheadedness, several of which were terminated by ICD shocks. On these occasions, he was fully conscious when shocked and was clearly emotionally impacted by the events, as he was now complaining of fear, anxiety, and a sense of impending doom. Device interrogation revealed multiple episodes of tachycardia with a fast ventricular rate (205–225 bpm), a 1:1 V-A relationship, and a V-A time of 50 ms (msec) (Fig. 1). In several cases, antitachycardia pacing (ATP) was able to successfully terminate the arrhythmia (Fig. 2). At other times, despite ventricular capture, ATP was unable to entrain the tachycardia. In those instances, the tachycardia persisted after ATP (Fig. 3). On two occasions, the tachycardia fell into the ventricular fibrillation (VF) zone, resulting in ICD shocks. Table 1 illustrates the device settings at the time of shock.

A diagnosis of AVNRT was strongly suspected on the retrospective review of the tachycardia episode, based on the short V-A time, the unchanged ventricular morphology on intracardiac electrograms, and the response to ATP. The patient was, therefore, scheduled for an electrophysiology (EP) study and possible radiofrequency catheter ablation. Meanwhile, in order to avoid further inappropriate shocks while awaiting the EP study, the VF zone was increased to greater than 233 bpm. At the EP study, dual AV nodal physiology was in fact revealed. A narrow complex tachycardia was reproducibly induced with single atrial extra-stimuli (Fig. 4). The tachycardia had a 1:1 VA relationship, a negative V-A time, and concentric atrial activation. Entrainment maneuvers were consistent with typical AVNRT. Slow pathway modification was performed, following which tachycardia was no longer inducible. Post-ablation, the device settings were returned to the primary prevention settings standard for our practice. On follow-up device interrogations, there have been no further episodes of tachycardia. The patient is relieved, but states that the anxiety caused by this experience has not completely resolved.

## Discussion

The aim of this analysis is to highlight potential difficulties in device discrimination of non-AF SVT from VT and to review what is known about existing options to prevent inappropriate treatment in such cases. The negative consequences of inappropriate shocks are several-fold. A single inappropriate shock results in increased mortality, with a hazard-ratio (HR) of 1.6. The risk further increases with each subsequent shock until up to a HR of 3.7 after 5 inappropriate shocks [7]. Significant behavioral disorders, psychological distress, and a negative impact on quality of life have also been described following ICD shocks [21–24]. Furthermore, inappropriate shocks are pro-arrhythmic and have the potential to cause malignant ventricular arrhythmias [25,26]. Finally, they also lead to more frequent clinic visits and hospitalizations, with a subsequent increase in healthcare costs [27,28].

An observational analysis of 426 patients reported that 13.6% of inappropriate ICD shocks were attributed to AVNRT; the incidence of AVNRT among ICD recipients was approximately 3.5% [29]. Current multi-society guidelines give a Class I indication to catheter ablation for the treatment of symptomatic AVNRT [30]. Catheter ablation targeting the slow pathway of the AV node has a success rate greater than 95%, with a risk of heart block requiring pacemaker implantation of only about 1% [31,32]. In other words, identifying ICD patients with AVNRT has the potential to reduce or eliminate inappropriate shocks, thereby improving patients' quality of life and possibly even their survival.

The commercially available algorithms used to discriminate SVT from VT differ depending on whether dual- or single-chamber sensing is available. In single-chamber sensing, the most used criteria are *electrogram morphology*, *interval stability*, and *suddenness of onset*. Both AVNRT and VT with 1:1 VA conduction typically have a *sudden onset* and *high interval stability*. Therefore, in single-chamber sensing, electrogram morphology is the only criterion capable of