

# Trouble Shooting of ICD Therapy: Inappropriate Shock

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Patients with an implantable cardioverter defibrillator (ICD) can undergo inappropriate therapies (shock or anti-tachycardia pacing) if electrical activity not originating in the ventricle is wrongly recognized as ventricular by the device. Inappropriate therapy leading to shocks is not innocuous; consequences include pain and its psychological sequelae, particularly anxiety, as well as induction of ventricular arrhythmias and decreased battery longevity. Inappropriate therapies might result from (1) detection of supraventricular tachyarrhythmias or (2) oversensing artifacts by the device. To avoid inappropriate therapies due to detection of supraventricular tachyarrhythmias, enhanced detection criteria, such as sudden onset and stability, have been developed. Sudden onset refers to the degree of prematurity of the initial beat of tachycardia with respect to the previous ones. Stability refers to the degree of regularity of arrhythmia. If programmed on, both criteria must be met to initiate the therapy. Previous history of atrial fibrillation and NYHA class I should be considered as risks for the occurrence of inappropriate therapies in single-chamber ICD recipients.

**Key Words:** Implantable cardioverter defibrillator • Ventricular arrhythmia • Supraventricular arrhythmia

## INAPPROPRIATE THERAPIES

Inappropriate therapies (shocks or antitachycardia pacing) occur in a certain proportion of patients with implantable cardioverter defibrillators (ICDs) and represent one of the most challenging aspects of management for the physician. Inappropriate therapies are usually very poorly tolerated by the patient, because they occur while the patient is conscious. Inappropriate therapy leading to shocks is not innocuous; consequences include pain, psychological sequelae, particularly anxiety, induction of ventricular arrhythmias, and decreased battery longevity.<sup>1,2</sup> The inappropriate therapies are often

caused by (1) detection of supraventricular tachycardia or (2) oversensing of artifacts by the device.

### Detection of supraventricular arrhythmia

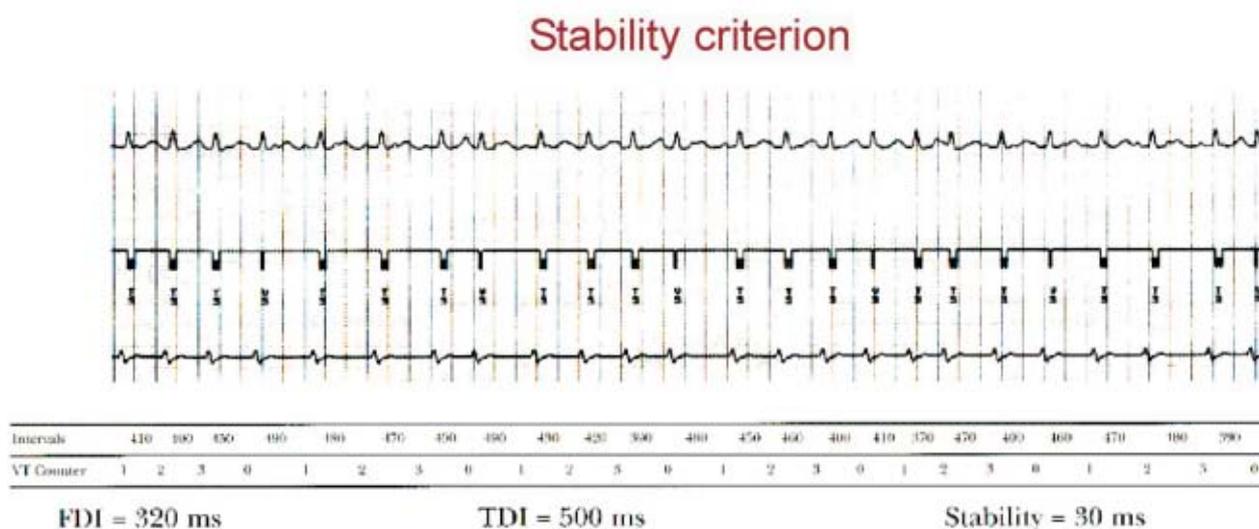
The ICD normally uses heart rate for a given period of time as the criteria for definition of arrhythmia. Any ventricular rate above the programmed cutoff rate is considered to be an arrhythmia and will be treated according to the programmed protocol. Some supraventricular arrhythmias such as sinus tachycardia, atrial fibrillation (Af), or atrial flutter can attain the programmed cutoff rate and thus be inappropriately treated.<sup>3,4</sup> Detection of supraventricular tachyarrhythmias is reported to affect 20-30% of patients with single-chamber ICDs. Sinus tachycardia and Af can account for up to 50% and 12% of these inappropriate therapies, respectively.<sup>5-8</sup>

### Oversensing by the device

Oversensing by the device refers to the presence of electrical activity that is not ventricular in origin but that is interpreted by the device as ventricular. This electrical

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**Figure 2.** Each interval is compared to the previous 3 VT intervals. It is counted as VT if the difference between the sensed interval and the previous 3  $\leq$  the programmed stability interval. VT count reset to zero if the difference between the sensed interval and the previous 3 is  $>$  the programmed interval. Stability criteria apply to both detection and redetection.

of the 261 patients (44%) received one or more inappropriate therapies (73% within 2 years of receiving their device). Significant predictors of inappropriate therapy by multivariate model were prior Af (OR 2.6, 95% CI 1.5-4.5) and NYHA class 1 vs. classes 2-4 (OR 2.2, 95% CI 1.2-3.7).

### Dual-chamber ICD and inappropriate therapies

Dual-chamber ICDs have been developed to prevent inappropriate therapies by differentiating supraventricular from ventricular tachycardia. Dual-chamber ICD allows combined benefits of DDD and ventricular tachycardia (VT)/ventricular fibrillation (Vf) therapy. Storage of both atrial and ventricular electrograms provides more information in elucidation of the nature of dysarrhythmias. However, according to the report of Fan et al,<sup>17</sup> inappropriate shocks, though reduced (15.8%), are still possible in patients receiving dual-chamber ICDs. The most common findings for inappropriate shocks were: (1) sinus tachycardia with first-degree heart block which was misdiagnosed as VT with retrograde 1:1 conduction; (2) AF with fast ventricular response within the VF zone.

Dual-chamber ICD (DDD-ICD) was compared with single-chamber ICD (VVI-ICD) in a randomized, prospective study on the ability to analyze atrial and ventricular arrhythmia.<sup>18</sup> This prospective study included 92 patients

(87 men; mean age  $61 \pm 12.7$  years) who were randomly assigned to a VVI-ICD (45 patients) or a DDD-ICD (47 patients). Both groups were followed for  $7.5 \pm 3.5$  and  $7.6 \pm 4.1$  months, respectively. During the follow-up period, overall 725 VT/VF episodes were recorded in 45 (49%) of 92 patients. Of these episodes, 404 (56%) occurred in the VVI-ICD group and 321 (44%) episodes occurred in the DDD-ICD group. Twenty-three (51%) patients in the VVI-ICD group and 22 (47%) patients in the DDD-ICD group ( $p = 0.8$ ) developed VT/VF. Overall, 73 (10%) of 725 treated episodes were inappropriate in 6 (13%) patients in the VVI group and in 10 (21%) patients in the DDD-ICD group ( $p = 0.2$ ). There were 22 (31%) inappropriately treated episodes in the VVI-ICD group and 51 (69%) in the DDD-ICD group. Thirty-two of the 51 inappropriate episodes in the DDD-ICD patients resulted from intermittent atrial sensing problems that led to failure of the respective dual-chamber algorithms. Nonfatal complications occurred in 6 (13%) patients in the VVI-ICD group and in 3 (6%) patients in the DDD-ICD group ( $p = 0.7$ ). According to the results of Deisenhofer et al,<sup>18</sup> although DDD-ICDs allow better rhythm classification, the applied detection algorithms do not offer benefits in avoiding inappropriate therapies during supraventricular tachyarrhythmias. More large series of studies are needed to verify the benefits of DDD-ICDs in differentiating atrial and ventricular ar-

rhythmia.

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