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Review

Identifying atrial arrhythmias versus pacing-induced rhythm disorders with state-of-the-art cardiac implanted devices

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ABSTRACT

Repetitive non-reentrant ventriculo-atrial synchrony (RNRVAS) is a pacemaker-induced arrhythmia that must be distinguished from atrial fibrillation (AF). Pacemaker-induced arrhythmias are commonly detected as atrial high rate episodes (AHRE) by implanted cardiac devices. Two main types of atrial oversensing are recognized: far-field R-wave (FFRW) oversensing and pacemaker-induced arrhythmias, which include pacemaker-mediated tachycardia and RNRVAS. The presence of ventriculo-atrial conduction is required for both types of pacemaker-induced arrhythmias. The incidence of RNRVAS can increase with the use of various device settings and functions, such as long atrioventricular (AV) interval programming, the rate-adaptive mode, and the atrial overdrive pacing algorithm. The negative aspects of pacemaker-induced arrhythmias, especially RNRVAS, include (1) loss of optimal AV delay, (2) inappropriate increase in ventricular pacing, (3) induction of atrial arrhythmias, and (4) inaccurate diagnosis of AHRE. We review the incidence of arrhythmias, electrophysiological mechanisms, and the clinical diagnosis of RNRVAS identified by using dual-chamber implantable cardiac devices.

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1. Introduction

The atrial high rate episode (AHRE) diagnostic function of implantable cardiac devices is often used to detect atrial tachyarrhythmias (ATA). However, its reliability and characteristics vary, depending on the device settings and use of other functions, such as the rate-adaptive mode or the atrial overdrive pacing (AOP) algorithm, especially in dual-chamber devices. The "*ASymptomatic atrial fibrillation and Stroke Evaluation in pacemaker patients and the atrial fibrillation Reduction atrial pacing Trial*" (ASSERT) examined the impact of device-detected, subclinical ATA on the development of strokes and systemic embolisms [1,2]. In that study, the presence of subclinical ATA was associated with a significant 2.5-fold higher risk of thromboembolic events in

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pacemaker or ICD recipients [2]. The diagnosis of subclinical ATA based on the presence of AHRE is critical information that should prompt the initiation of appropriate preventive therapies, such as long-term oral anticoagulation or antiarrhythmic medications.

The presence of AHRE, however, may not invariably indicate the presence of ATA. We have recently reported AHRE that reflected episodes of atrial fibrillation (AF) as well as device-mediated arrhythmic events, such as repetitive non-reentrant ventriculo-atrial synchrony (RNRVAS), pacemaker mediated tachycardia (PMT), and far-field R wave (FFRW) oversensing, particularly in the presence of long atrioventricular (AV) intervals in the DDD mode, or when rate-responsive pacing or an AOP algorithm was used in recipients of a dual-chamber pacemaker or an implantable cardioverter defibrillator [3]. RNRVAS or PMT require ventriculo-atrial (VA) conduction to develop.

2. Atrial setting in dual-chamber devices

An optimal setting of atrial sensitivity is key for the accurate detection of ATA by implantable dual-chamber pacing devices. To optimize AF detection and lower the risk of atrial undersensing by dual-chamber implanted devices, a setting of a <0.5 mV atrial sensitivity is usually recommended. The setting of a low atrial sensitivity lowers the risk of FFRW oversensing as well as lowering the chances of detecting ATA, due to undersensing the atrial electrogram during ongoing tachyarrhythmia. In this case, the incidence of ATA may be underestimated. Conversely, a setting of high atrial sensitivity increases the chances of detecting ATA and increases the likelihood of FFRW oversensing, in which case the incidence of clinical ATA may be overestimated. Although the optimal atrial sensitivity remains to be defined, a <0.5 mV setting is generally recommended for recipients of implantable devices who have a history of AF. However, high atrial sensitivity settings might cause atrial oversensing. Table 1 shows the pitfalls for diagnosing AF. In the presence of atrial undersensing (when the atrial sensitivity is low), the incidence of true AF cannot be detected accurately. Atrial oversensing may result in (1) double counts of the P wave, which includes RNRVAS and FFRW oversensing, or (2) sensing of myopotentials, lead noise, or electromagnetic interference. Atrial undersensing and oversensing may both interfere with the diagnosis of true AF.

Table 1
Atrial sensing in dual-chamber devices.

Atrial undersensing
• **True atrial fibrillation**
• **Functional atrial fibrillation**
Atrial oversensing
• **Repetitive non-reentrant VA synchrony (RNRVAS)**
• **Pacemaker mediated tachycardia (PMT)**
• **Far-field R wave (FFRW) oversensing**
• **Myotonic potentials**
• **Lead failure**
• **Electromagnetic interference**
• **Other**

3. Device-detected non-atrial fibrillation

State-of-the-art, implantable, dual-chamber cardiac devices provide useful diagnostic information, including the number and duration of automatic mode switch (AMS) episodes upon detecting ATA. However, to collect accurate diagnostic information, special attention must be paid to the device settings, to the presence versus absence of VA conduction, which when present, often represents RNRVAS or PMT, to the post-ventricular atrial blanking period (PVAB) and atrial sensitivity, and to the sensing of FFRW in the atrial channel. Preventing FFRW sensing by the atrial channel is challenging as it is inversely correlated with the duration of the PVAB and with the atrial sensitivity. Furthermore, the presence of VA conduction may cause RNRVAS or PMT. Although FFRW sensing, RNRVAS, and PMT are not ATA, they (a) are counted as ATA episodes by implantable monitoring devices, (b) might be the source of inaccurate diagnostic information and inappropriate AMS from DDD to DDI or VVI mode, and (c) may trigger ATA or cause pacemaker syndrome [4–14]. The clinical shortcomings associated with atrial oversensing are shown in Fig. 1.

Increasing the duration of PVAB might be an effective means of preventing FFRW oversensing in the atrial channel. However, this narrows the search window of atrial sensing, and shortens the window of ATA detection, which might decrease the likelihood of detecting ATA. Conversely, a short PVAB widens the search window of atrial sensing and of ATA detection, a setting that might decrease the specificity of ATA detection. In clinical practice, therefore, a $+25$ ms PVAB setting between the ventricular pacing spike and FFRW sensing is generally recommended [15].

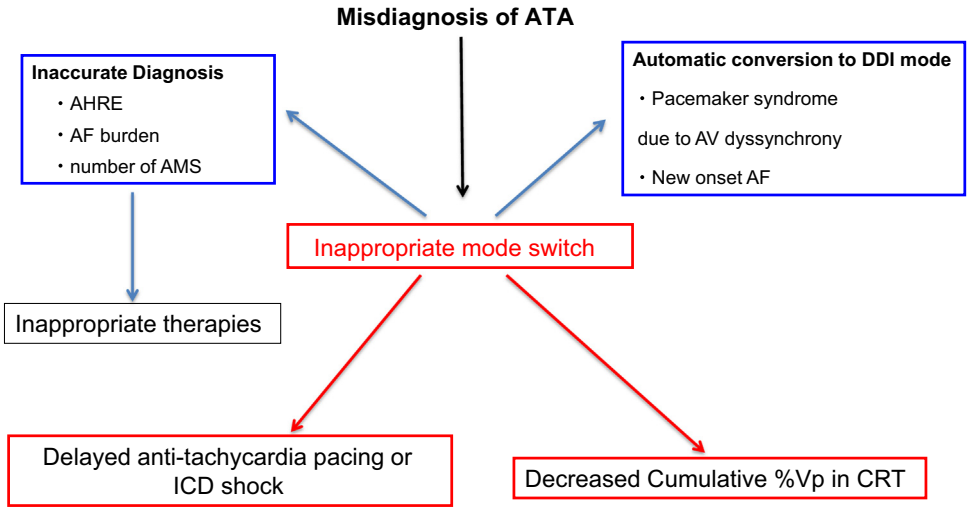

Fig. 1. Adverse effects of atrial oversensing. AHRE, atrial high rate episode; ICD, implantable cardioverter defibrillator; CRT, cardiac resynchronization therapy; AF, atrial fibrillation; AV, atrioventricular; AMS, auto mode switch; Vp, paced ventricular event.