Repetitive non-reentrant ventriculo-atrial synchrony induced atrial fibrillation terminated with inappropriate shock

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Abstract
Repetitive nonreentrant ventriculo-atrial synchrony (RNRVAS) is an arrhythmia which occurs in patients with dual-chamber devices and requires an intact ventriculo-atrial conduction. It can present with symptoms similar to those of pacemaker-mediated endless loop tachycardia and is an example of functional atrial undersensing and functional loss of atrial capture. In addition to loss of optimal atrioventricular (AV) delay and inappropriate ventricular pacing, RNRVAS may trigger atrial arrhythmias and cause serious complications. We report a case of RNRVAS-induced atrial fibrillation (AF) terminated with implantable cardioverter defibrillator (ICD) shock in a 74-year old female with no prior history of AF.

1. Case report
A 74-year-old woman with ischemic cardiomyopathy received a dual-chamber ICD (St Jude Medical Fortify Assura CD2357) for sustained ventricular tachycardia (VT) in 2007. Her device was programmed DDDR 60–110 bpm with a VT zone of 181 beats per minute (bpm) and a ventricular fibrillation (VF) zone of 200 bpm. The sensed and paced AV delay were 225 and 250 ms, respectively. An alert remote transmission was received for an episode of “ventricular fibrillation”. Device interrogation revealed sinus rhythm with 17% atrial pacing and <1% ventricular pacing. Atrial fibrillation burden was <1%. She had 113 mode-switching episodes for RNRVAS (Fig. 1). This resulted in induction of AF after an atrial-paced event was delivered during atrial refractoriness (Fig. 2). One of these events was associated with a rapid ventricular response with rates accelerating into the VF zone (203 bpm). This was detected as a VF episode and the device delivered one burst of anti-tachycardia pacing (ATP) during charging which was not successful. This was followed by a 36-J shock that was able to terminate the arrhythmia (Fig. 3 B).

The patient was then brought to the clinic for further evaluation. Device interrogation revealed a VA conduction time of 220 ms and the post-ventricular atrial refractory period (PVARP) was set to “auto” with rate responsive PVARP set to low at 275 ms. In addition to shortening the paced AV delay to 200 ms, the rate responsive PVARP was turned off and the PVARP was set to the lowest value of 225 ms. Following adjustment in the device settings, there were no more episodes of RNRVAS or AF noted on the 3-month follow up visit.

2. Discussion
RNRVAS is a well-recognized complication of dual-chamber devices [1]. This type of arrhythmia occurs when a retrograde P wave falls within the PVARP “functional undersensing” and is followed by an atrial stimulus that does not capture because both atria are still in a refractory state from the previous retrograde P wave, i.e. functional non-capture. At the end of the programmed atrioventricular delay, the device delivers a ventricular stimulus that leads to another retrograde P wave and, therefore, perpetuates the RNRVAS rhythm. Typically, RNRVAS is initiated by a single premature ventricular contraction. Factors that shorten the atrial escape interval, such as long AV delay and/or a relatively short lower rate interval, predispose to the development of RNRVAS [2]. In general, detected episodes of RNRVAS are likely to be misinterpreted by the device as atrial arrhythmias (atrial tachycardia (AT)/AF) [3]. In our case, various phenomena due to ventriculo-atrial conduction including pacemaker-mediated tachycardia and RNRVAS led to...
premature atrial pacing due to functional undersensing, which could have led to AF that was terminated by an inappropriate shock. To our knowledge, this is the first case report of RNRVAS-induced AF that eventually led to inappropriate therapy. We have no clear explanation why she developed AF during the RNRVAS event. However, there are data showing that atrial pacing increases the risk of atrial fibrillation [4,5]. We hypothesize that the atrial stimulus delivered during the RNRVAS episode fell in the atrial relative refractory period which in turn triggered atrial fibrillation. Since the ventricular rate fell in the VF zone, no discrimination criteria were used and, rather, programmed therapy was delivered. Interestingly, retrogradely-conducted P waves without subsequent atrial pacing have also been shown to occasionally induce AF [6].

Electrophysiologists should be aware of RNRVAS as a cause of “mode-switching” episodes in patients with dual-chamber devices. Our case also emphasizes the role of stored electrograms in depicting the course of management in such patients, which would usually require adjustment of the device settings by shortening the paced AV delay and/or decreasing the lower pacing rate.

3. Conclusion

RNRVAS is an arrhythmia seen in patients with dual-chamber devices. It requires an intact ventriculo-atrial conduction and represents an example of functional atrial undersensing and functional loss of atrial capture. In addition to the potential for causing atrial arrhythmias, serious consequences (such as an inappropriate shock) could also ensue. Electrophysiologists should be aware of this arrhythmia as a cause of “mode-switching” episodes in patients with dual-chamber devices. Our case also emphasizes the role of stored electrograms in depicting the course of management in such patients, which would usually require adjustment of the device settings by shortening the paced AV delay and/or decreasing the lower pacing rate.

Fig. 1. Initiation of repetitive non-reentrant ventriculo-atrial synchrony (RNRVAS). The first three beats likely represent a short run of pacemaker-mediated tachycardia. The fourth ventricular beat (VS), which is likely a premature ventricular contraction, conducts retrogradely to the atrium and the P wave falls in the post-ventricular refractory period. This is followed by an atrial-paced beat which initiates the arrhythmia. AMS: automatic mode switching; AP: atrial paced event; AS: atrial sensed event; VP: ventricular paced event; VS: ventricular sensed event; SIR: sensor-initiated rate.
Fig. 2. Precipitation of atrial fibrillation. An atrial paced beat is delivered during atrial refractoriness which initiates atrial fibrillation. Abbreviations are the same as Fig. 1.
Fig. 3. Inappropriate shock for atrial fibrillation with a rapid ventricular response. The ventricular rate during atrial fibrillation eventually accelerates into the ventricular fibrillation zone (A). This is detected by the device and one scheme of anti-tachycardia pacing (ATP) is delivered during charging which fails to terminate the arrhythmia. This is followed by a 36-J shock with eventual return of normal sinus rhythm (B). Abbreviations are the same as in Fig. 1.
Fig. 3. (continued).
Conflict of interest
None.

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