The V-A-V Response to Ventricular Entrainment During Atrial Tachycardia: What Is the Mechanism?

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Case Presentation

A 46-year-old male was admitted to our emergency department due to a narrow QRS tachycardia of 230 bpm with impeding hemodynamic collapse. His only remarkable medical history was mild hypertension. Adenosine administration was ineffective in stopping the tachycardia, and sinus rhythm was restored using an electrical cardioversion. A few weeks later, during an electrophysiology study an identical tachycardia was immediately induced during the introduction of diagnostic catheters into the right atrium (Fig. 1, upper panel). A rate-related right bundle branch block aberration was present for most of the time. Atrial activation was simultaneous with ventricular activation, ruling out atrioventricular reentrant tachycardia (AVRT), and suggesting atrioventricular nodal reentrant tachycardia (AVNRT) (Fig. 1, lower panel). To confirm the absence of atrial tachycardia, ventricular entrainment pacing using a cycle length shorter by 30 milliseconds than the tachycardia cycle length was performed. The atrial rate accelerated to the pacing rate (Fig. 2), and when ventricular (V) pacing was ceased, the activation sequence was the last entrained atrium (A) followed by the ventricle (V) (i.e., a V-A-V response). Such a response is considered to rule out atrial tachycardia and these findings were repeatable. Therefore, by exclusion of all other possible causes a diagnosis of AVNRT could have been considered irrefutable. However, long VA interval during entrainment and the atrial activation sequence with atrial depolarization later on His catheter than on high right atrial catheter (Fig. 1, lower panel) were not compatible with slow-fast AVNRT, either. Moreover, multiple attempts to stop the tachycardia with fast ventricular and atrial burst pacing failed. This prompted a more detailed assessment of the atrial activation sequence and an analysis of entrainment from the right atrium. Those analyses both led to an unquestionable diagnosis of a macroreentrant right atrial tachycardia with a reentrant circuit identical to that observed in a typical clockwise atrial flutter, albeit slower, which resulted in a rate below the arbitrary threshold of 250 bpm for a diagnosis of atrial flutter. The patient underwent cavotricuspid isthmus ablation with creation of a bidirectional block. No tachycardia was inducible following treatment.

The arrhythmia was promptly diagnosed and cured; however, a puzzling question remained: How can it be possible that after ventricular entrainment, a V-A-V rather than a V-A-A-V response was present?

Commentary

During narrow QRS tachycardia with a 1:1 AV relationship, the differential diagnosis includes AVNRT, AVRT, and atrial tachycardia/flutter. Ventricular entrainment pacing in such a situation is a powerful differentiating tool.[1,2] In the case of an atrial tachycardia, following cessation of ventricular overdrive pacing (which accelerates the tachycardia to the ventricular pacing rate), the last "entrained" atrial depolarization cannot conduct in an anterograde manner. This is because the AV node is refractory after recent retrograde conduction. The result is 2 atrial depolarizations between ventricular depolarizations, i.e., a sequence of activation known as a V-A-A-V response. It is widely accepted that in the contrary situation where the last entrained retrograde atrial depolarization does conduct anterogradely and results in a V-A-V response, atrial tachycardia is essentially excluded from the diagnosis, and that the tachycardia mechanism involves a reentrant circuit that includes the AV node.[1,3] However, it appears that the current case is an example of an exception to these accepted assumptions.

In macroreentrant atrial tachycardia/flutter, the last entrained atrial depolarization can conduct anterogradely if the conduction time in the atrial macroreentrant circuit is longer than the AV junction refractory period (Fig. 3), which is always the case when a 1:1 AV relationship during tachycardia was previously present. However, there is one caveat: to observe the V-A-V rather than the V-A-A-V sequence, the electrode that registers the atrial activity has to be outside of the collision zone in the reentrant circuit and outside of the area between the reentrant circuit and the AV node. Interestingly, such a situation is the rule rather than the exception in cases of a common atrial flutter or macroreentrant tachycardia with a similar reentrant circuit, since the collision zone is very small and the AV node is in very close proximity to the reentrant circuit. If the right atrial catheter is in a standard position on the high lateral wall of the right atrium

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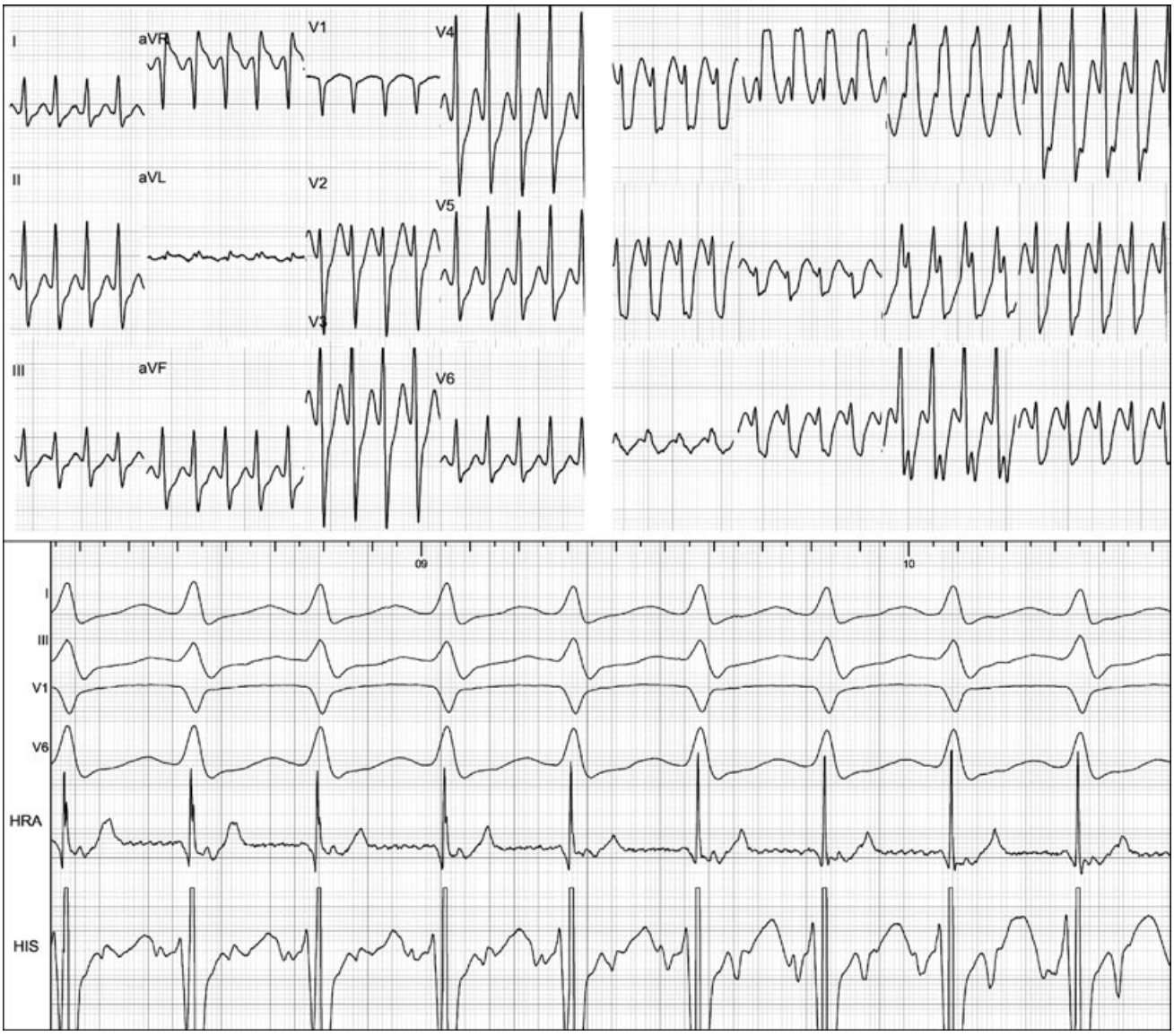

Figure 1. *Upper panel: A 12-lead ECG showing clinical tachycardia without and with the rate-related right bundle branch block aberration, paper speed 25 mm/s. Lower panel: Clinical tachycardia with intracardiac tracings, paper speed 100 mm/s, HRA = high right atrium.*

then it is likely that a V-A-V response will also be seen in right atrial free wall flutters/macroreentrant tachycardia cases.

The possibility that entrainment of an atrial macroreentrant tachycardia can result in a V-A-V response was not considered previously, and to our knowledge such a phenomenon has never previously been described by others.[1] Indeed, there do not appear to be any serious challenges to the rule that a V-A-V response excludes a diagnosis of atrial tachycardia. Some authors have described an apparent V-A-V response during atrial tachycardia; however, that was in reality a pseudo-V-A-V response resulting from AV dissociation that was mistaken for "entrainement."[4] Others have described a so-called "pseudo-V-A-A-V" response during AVNRT or AVRT. Such a response can result from AV dissociation,[5] or from a mistake in identifying the last entrained atrial depolarization due to a long VA interval that exceeds the paced cycle length.[6] Such a "pseudo-V-A-A-V" response is really a V-A-V response. Indeed, the response in the current case could also be considered a borderline "pseudo V-A-A-V" since the last paced "V" was simultaneous with the "A" caused by the previous "V."

Ventricular overdrive pacing resulting in entrainment rather than in AV dissociation during such a fast atrial tachycardia is rather unusual and resulted, in the current case, from the concurrent enhanced atrioventricular nodal conduction. In the present patient, the AV junction was capable of 1:1 conduction up to 250 bpm anterogradely and 260 bpm retrogradely (without isoprenaline and during mild sedation), the AH interval was very short (40 milliseconds) and was prolonged only minimally with pacing or with adenosine administration (the maximum AH was 70 milliseconds), the HV interval was stable and normal (48 milliseconds), and the retrograde activation sequence was concentric.

In conclusion, the current case demonstrates that a macroreentrant atrial tachycardia should also be considered in the differential diagnosis when a V-A-V response after ventricular overdrive pacing is present.

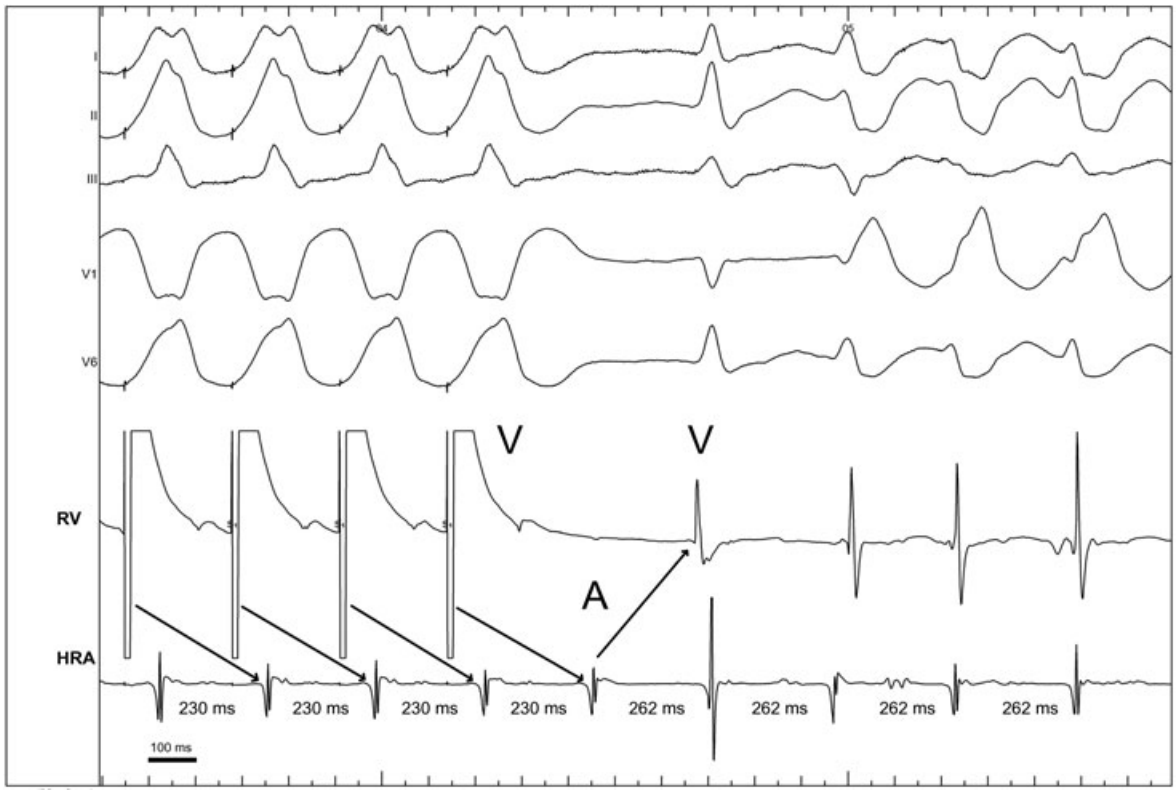

Figure 2. *Ventricular overdrive pacing from the right ventricle (RV) with a cycle length of 230 milliseconds resulting in entrainment of the atrial macroreentrant tachycardia. The last entrained atrial depolarization (A) registered by the high right atrial catheter (HRA) was conducted to the ventricles resulting in a V-A-V response. The tachycardia resumed its cycle length of 262 milliseconds. The first intrinsic ventricular depolarization was narrow because of the resolution, after a pause, of the rate-related right bundle branch block. Note that apart from the V-A-V response there was simultaneous activation of the atrium and the ventricle and that the post pacing interval was much longer than the tachycardia cycle length, all of which mimics AVNRT.*

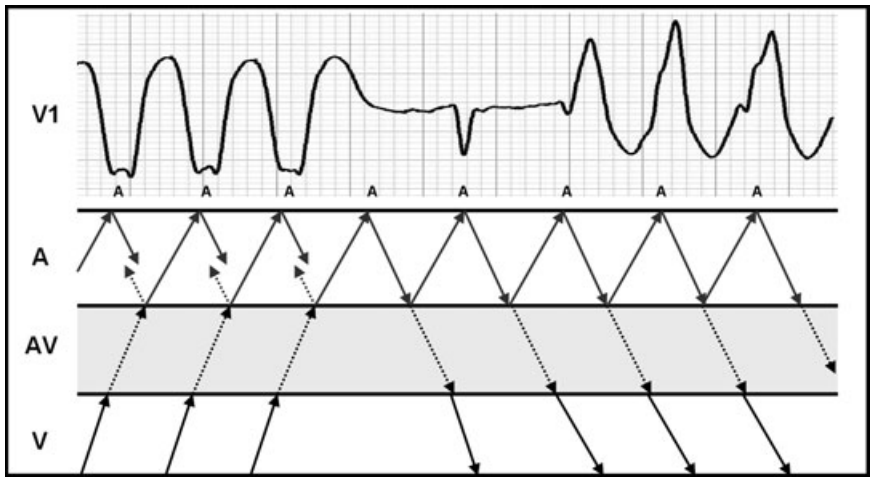

Figure 3. *Lewis diagram. The time point shown in this figure is the same as that represented in Figure 2. The data explain the V-A-V response mechanism during atrial flutter or atrial reentrant tachycardia. V1 = surface lead; A = atrium; AV = atrioventricular node; V = ventricle. The letter "A" represents atrial depolarization as detected by a high right atrial catheter.*

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