Extent of Atrial Participation in Atrioventricular-Reciprocating Tachycardia

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SUMMARY Twenty-one patients with atrioventricular (AV) bypass tracts underwent electrophysiologic studies. The bypass tract was left-sided in 15 patients, septal in five and right-sided in one patient. Orthodromic AV-reciprocating tachycardia was induced in all 21 patients, with a mean tachycardia cycle length of 342 ± 59 msec. The introduction of single stimuli in the high right atrium during tachycardia resulted in simultaneous dissociation of the high right atrial and low septal atrial electrograms in nine patients. In six patients, high right atrial overdrive pacing during tachycardia resulted in simultaneous dissociation of the high right atrial and low septal atrial electrograms for two to five consecutive beats. All patients in whom the low septal atrial electrogram was dissociated from the tachycardia had a left-sided bypass tract. In no patient was the coronary sinus atrial electrogram dissociated from the tachycardia by high right atrial pacing.

Dissociation of the low septal atrial electrogram (as recorded in the His bundle electrogram) from AV-reciprocating tachycardia suggests that the portion of the right atrium adjacent to the AV node may not be a necessary link in the tachycardia circuit. This observation suggests that the site of entry of left-sided impulses into the AV node may be different from that of right-sided impulses.

IN PATIENTS with atrioventricular (AV) nodal reentrant tachycardia, a premature atrial extrastimulus introduced during the tachycardia may result in premature capture of the atria without disruption of the tachycardia. This observation has been cited as evidence that the atrium is not a necessary link in the reentry circuit in patients with AV nodal reentrant tachycardia. In contrast, the atrium is a necessary link in AV-reciprocating tachycardia using an AV bypass tract, because the bypass tract inserts into atrial tissue. However, the degree of atrial involvement in the reentry circuit in AV-reciprocating tachycardia is unclear. In this study, we report on the extent of atrial participation in AV-reciprocating tachycardia as assessed by the response to high right atrial pacing during tachycardia.

Methods

Twenty-one patients with recurrent paroxysmal supraventricular tachycardia using an AV bypass tract were studied in the electrophysiology laboratory. The mean age was 42 ± 17 years (± sd). After they gave informed consent, the patients were studied in the fasting, nonsedated state. Three quadripolar electrode catheters were inserted into a femoral vein and positioned against the high lateral right atrium, across the tricuspid valve and against the right ventricular apex. Another quadripolar electrode catheter was inserted into an antecubital or subclavian vein and positioned in the coronary sinus. Surface leads V1, I and III and the high right atrial, His bundle and coronary sinus electrograms were recorded on a VR-12 Electronics for Medicine recorder. Atrial and ventricular stimuli were delivered by a programmable stimulator (Bloom, Inc.) at two to three times the diastolic threshold with a pulse duration of 2 msec. Incremental high right atrial and coronary sinus overdrive pacing was performed to a minimal paced cycle length of 250 msec. During overdrive pacing at a cycle length of 500 msec for five beats, single atrial and ventricular stimuli were introduced at 10-msec decrements throughout the respective diastolic cycles. During induced tachycardia, the atrium and ventricle were scanned with progressively premature right atrial and ventricular extrastimuli. In addition, during tachycardia, high right atrial overdrive pacing was performed at cycle lengths 15–100 msec shorter than the tachycardia cycle length.

Three criteria were used to establish the participation of an AV bypass tract in the tachycardia circuit: an identical pattern of eccentric atrial activation during ventricular pacing and tachycardia;3 prolongation of the ventriculoatrial (VA) conduction time with the development of bundle branch block during tachycardia;4 and premature depolarization of the atria during tachycardia by a ventricular stimulus delivered when the His bundle is refractory.4–6

The atrial electrogram was considered to be dissociated from the tachycardia if atrial stimulation resulted in advancement of the atrial electrogram by at least 20 msec with no change in the ventricular cycle length of the tachycardia.

Results

Orthodromic AV-reciprocating tachycardia was induced in all 21 patients. The mean cycle length of the tachycardia was 342 ± 59 msec. The AV bypass tract was left-sided in 15 patients, septal in five and right-sided in one patient. In seven patients, the bypass tract was "concealed," i.e., capable of only retrograde conduction, whereas in 14 patients the bypass tract conducted impulses in both an antegrade and retrograde direction.

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Response to Single Atrial Stimuli During Tachycardia

During tachycardia, the introduction of single stimuli in the high right atrium at coupling intervals 20–100 msec shorter than the tachycardia cycle length resulted in simultaneous dissociation of the right atrial and low septal atrial electrograms in nine patients (fig. 1). In four other patients, the high right atrial electrogram alone was dissociated from the tachycardia. These 13 patients all had a left-sided bypass tract. In no patient was the coronary sinus atrial electrogram dissociated from the tachycardia.

In one of the patients who had a left-sided bypass tract, a spontaneous premature atrial depolarization occurred during tachycardia with dissociation of the high right atrial and low septal atrial electrograms from the tachycardia (fig. 2).

Response to High Right Atrial Overdrive Pacing During Tachycardia

In six patients, high right atrial overdrive pacing resulted in simultaneous dissociation of the right atrial and low septal atrial electrograms for two to five consecutive beats (figs. 3 and 4). These six patients all had a left-sided bypass tract. In five other patients (two with a septal bypass tract, one with a right-sided bypass tract, and two with a left-sided bypass tract), the high right atrial electrogram alone was dissociated from the tachycardia for two to four consecutive beats. In the remaining 10 patients, high right atrial overdrive pacing resulted in either immediate entrainment or termination of the tachycardia.

During high right atrial overdrive pacing, the coronary sinus atrial electrogram was never dissociated from the tachycardia, regardless of the position of the recording electrode catheter in the coronary sinus relative to the bypass tract. In the 20 patients who had a left-sided or septal bypass tract, atrial mapping demonstrated a minimum VA conduction time of 85–135 msec. When high right atrial overdrive pacing was performed during tachycardia, the VA conduction

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**Figure 1.** Atrioventricular (AV)-reciprocating tachycardia using a left-sided AV bypass tract. Electrocardiographic leads V1, I, and III, intracardiac electrograms recorded from the high right atrium (HRA) and coronary sinus (CS), and the His bundle electrogram (HBE) are shown. Time lines represent 1-second intervals. The tachycardia cycle length is 320–325 msec. A single atrial extrasystole (S) introduced in the HRA results in advancement of the right atrial and low septal atrial electrograms, with no change in the RR cycle length or in the cycle length of the CS atrial electrogram. There is a compensatory pause (375 msec) after the right atrial and low septal electrograms. The numbers above the electrocardiographic and intracardiac recordings represent the RR cycle length and the cycle length of the atrial electrograms, respectively. H = His bundle depolarization; V = ventricular depolarization; A = atrial depolarization.

**Figure 2.** A spontaneous atrial premature depolarization (APD) occurs during atrioventricular (AV)-reciprocating tachycardia using a left-sided AV bypass tract. During the tachycardia, the earliest atrial depolarization is recorded in the coronary sinus (CS). The APD results in dissociation of the right atrial and low septal atrial electrograms but not in the CS atrial electrogram; there is no change in the RR cycle length. Abbreviations are as in figure 1.
time measured from the coronary sinus electrogram was within 55 msec of the minimum VA conduction time.

Discussion

The most significant finding in this study is the observation that the atrium in the area of the AV node (as recorded in the His bundle electrogram) can be dissociated from AV-reciprocating tachycardia using a left-sided bypass tract. Thus, although the AV node itself is a component of the reentry circuit, the low right atrial tissue adjacent to the AV node appears to not be a necessary link in the tachycardia circuit.

When a single atrial premature depolarization is introduced during AV-reciprocating tachycardia, it may penetrate the tachycardia circuit and conduct down the AV node. If the delay in AV conduction is equal to the degree of prematurity of the atrial depolarization, there will be no change in the tachycardia cycle length; one might therefore incorrectly conclude that the atrium had been dissociated from the tachycardia. Thus, on the basis of the response to a single atrial stimulus during tachycardia, one cannot determine whether dissociation of the atrial electrogram is real. However, in our study, with atrial overdrive pacing, the low septal atrial electrogram was dissociated from the tachycardia for two to five consecutive beats in six patients. A fortuitous lack of change in the tachycardia cycle length during several consecutive beats is less likely than when only a single atrial stimulus is introduced during the tachycardia. Furthermore, our findings cannot be explained by entrainment, because the rate of the tachycardia did not increase to the paced rate. Because the finding of atrial dissociation during tachycardia was reproducible and occurred at several pacing rates, we believe that the atrial dissociation was a real phenomenon in which the underlying tachycardia continued and was transiently unaffected by capture of the low septal atrial electrogram. The phenomenon was transient because the atrial pacing either entrained or terminated the tachycardia.

Dissociation of the low septal right atrial electrogram from AV-reciprocating tachycardia using a left-sided bypass tract demonstrates that the low septal right atrial electrogram does not define when left-sided impulses penetrate the AV node. This suggests that the site of entry of left-sided impulses into the AV node may be different from that of right-sided impulses. Dual input into the AV node has been reported in the rabbit heart. In addition, morphologic observations in the human AV node have demonstrated mitral and tricuspid extensions of the portion of the AV junctional areas in contact with atrial myocardium; these extensions of the AV node may represent the structural basis for dual input into the AV node. The concept of dual inputs into the AV node is also supported by the observation that the interval between the low septal right atrial electrogram and the His bundle depolarization is consistently shorter during atrial pacing from the coronary sinus than from the high right atrium. Alternatively, AV nodal conduction may be influenced by the direction of atrial input into the AV node, as reported in the isolated rabbit heart.

In the five patients who had a septal bypass tract, the low septal atrial electrogram was never dissociated from AV-reciprocating tachycardia. This may reflect
greater involvement of the atrium adjacent to the AV node in the tachycardia circuit when the bypass tract is itself near the AV node.

Dissociation of the high lateral right atrium in the one patient in this series who had a right-sided bypass tract indicates that only a lower portion of the right atrium may be a necessary link in the tachycardia circuit. However, because only one patient in this series had a right-sided bypass tract, no conclusions can be drawn regarding the extent of right or left atrial involvement in AV-reciprocating tachycardia that uses a right-sided bypass tract.

In contrast to the right atrial and low septal atrial electrograms, the coronary sinus atrial electrogram was never dissociated from the tachycardia, even when the recording catheter in the coronary sinus was distant to the site of the bypass tract. This suggests that the portion of the left atrium recorded in the coronary sinus electrogram may be a necessary link in the reentry circuit in patients who have a left-sided or septal bypass tract. However, although dissociation of a particular atrial electrogram from a tachycardia suggests that that portion of the atrium is not a required link in the tachycardia circuit, the converse is not necessarily true. Proximity to the site of stimulation may be an important factor in the ability to dissociate a portion of the atrium from the tachycardia. A limitation of this study is that overdrive pacing from the coronary sinus was not consistently performed during tachycardia. Therefore, although the coronary sinus atrial electrogram was never dissociated from AV-reciprocating tachycardia, we cannot conclude that the left atrium in the region of the coronary sinus is a necessary link in the reentry circuit. In addition, because the left atrial electrogram was recorded only from the coronary sinus, no conclusions can be drawn regarding involvement of other portions of the left atrium in AV-reciprocating tachycardia.

We conclude that the low septal right atrial electrogram may not be a necessary component of the reentrant circuit in AV-reciprocating tachycardia using a left-sided bypass tract. Dissociation of the low septal right atrial electrogram during AV-reciprocating tachycardia suggests different left-sided and right-sided in-
puts into the AV node in at least some patients with left-sided bypass tracts.

References
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