Entrainment for Distinguishing Atypical Atrioventricular Node Reentrant Tachycardia From Atrioventricular Reentrant Tachycardia Over Septal Accessory Pathways With Long-RP Tachycardia

Matthew T. Bennett, MD; Peter Leong-Sit, MD; Lorne J. Gula, MPH, MD; Allan C. Skanes, MD; Raymond Yee, MD; Andrew D. Krahn, MD; Ellaina C. Hogg, BSc; George J. Klein, MD

Background—The response to right ventricular (RV) entrainment is useful to distinguish atypical AV node reentrant tachycardia (AVNRT) from AV reentrant tachycardia (AVRT) using a septal accessory pathway. Whether entrainment can differentiate between AV node reentrant tachycardia and AV reentrant tachycardia in patients with long-RP tachycardia has not been systematically validated.

Methods and Results—Twenty-four patients with concealed septal accessory pathways who had an electrophysiology study between January 1, 2000, and January 1, 2010, were included (age, 38 ± 17 years; men, 17). Entrainment was performed from the RV apex pacing at cycle length 20 to 40 ms shorter than tachycardia cycle length (TCL). The mean TCL was 390 ± 80 ms, the mean AH interval during tachycardia was 151 ± 57 ms, and the mean ventriculoatrial (VA) time was 182 ± 103 ms. Twelve patients had typical accessory pathways (VA/TCL < 40%), and 12 had slowly conducting accessory pathways (VA/TCL ≥ 40%). In all patients with typical accessory pathways, the postpacing interval minus the TCL (PPI–TCL) was < 115 ms and the difference in the VA interval during pacing and tachycardia (Stima–VA) was < 85 ms. On the other hand, in 6 of the 12 patients in the slowly conducting group, the PPI–TCL was > 115 ms, and the Stima–VA was > 85 ms.

Conclusions—Slowly conducting accessory pathways frequently yield RV entrainment criteria traditionally attributable to AV node reentry. Distinguishing AV node reentry from AV reentry in patients with long-RP tachycardia requires other criteria. (Circ Arrhythm Electrophysiol. 2011;4:506-509.)

Keywords: arrhythmia ■ electrophysiology ■ tachycardia ■ diagnosis

Right ventricular (RV) entrainment commonly is used at the time of an electrophysiology study to distinguish atypical AV node reentrant tachycardia (AVNRT) from AV reentrant tachycardia (AVRT) using a septal accessory pathway. The proximity of the pacing site and its accessibility to the circuit result in relatively greater postspacing intervals (PPIs) and ventriculoatrial conduction times in AVNRT versus AVRT over a septal accessory pathway. In AVNRT, the difference between the PPI and the tachycardia cycle length (PPI–TCL) is > 115 ms.1 Similarly, the difference in the ventriculoatrial (VA) interval during pacing and tachycardia (Stima–VA) is > 85 ms in AVNRT.1 The opposite is true in AVRT where the PPI–TCL is < 115 ms, and the Stima–VA is < 85 ms.1 These criteria have been assessed for tachycardia in which the retrograde limb is not a slowly conducting septal accessory pathway where rate-related prolongation of conduction time often is encountered.

We sought to assess whether entrainment maneuvers during AVRT using a slowly conducting concealed septal accessory pathway could similarly distinguish them from AVNRT.1

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Methods

All patients with a slowly conducting concealed septal accessory pathway in whom tachycardia entrainment from the RV apex was performed between January 1, 2000, and January 1, 2010, were included. Also included were an equal number of patients with a normally conducting concealed septal accessory pathway in whom tachycardia entrainment from the RV apex was performed. A septal accessory pathway as the retrograde limb of AVRT was diagnosed when a central activation sequence (earliest atrial depolarization during AVRT at the His or coronary sinus orifice region) during supraventricular tachycardia was observed in conjunction with published confirmation criteria, as follows: (1) The tachycardia was advanced, delayed, or terminated by a premature ventricular depolarization programmed into the cycle when the His bundle was programmed.
refractory; (2) the VA interval during tachycardia increased by ≥10 ms with the development of a functional bundle branch block; and (3) differential ventricular entrainment during tachycardia showed a PPI–TCL that was greater at the RV apex than at the base.5–8 Figure 1 illustrates an example of delayed atrial depolarization with a premature ventricular depolarization that occurred when the His bundle was refractory. Patients were defined arbitrarily on the basis of previous cases at our institution as having a slowly conducting accessory pathway if the VA/TCL was ≥40% and, conversely, as having a normally conducting accessory pathway if the VA/TCL was <40%.

Entrainment of the tachycardia was attempted with RV apical pacing at a cycle length of 20 to 40 ms shorter than the TCL. The PPI was defined as the interval from the stimulation artifact on the RV apical electrode and the rapid deflection of the atrial electrogram at the coronary sinus orifice or His bundle (earliest). The VA interval was measured during pacing (StimA) as the interval between the onset of the QRS complex on the RV apical electrode and the rapid deflection of the next sensed atrial electrogram at the coronary sinus orifice or His bundle (earliest). The VA interval was measured during pacing (StimA) as the interval between the onset of the QRS complex on the RV apical electrode and the rapid deflection of the atrial electrogram at the coronary sinus orifice or His bundle (earliest). The VA was measured during pacing (StimA) as the interval between the onset of the QRS complex on the RV apical electrode and the rapid deflection of the atrial electrogram at the coronary sinus orifice or His bundle

Continuous variables are expressed as the mean ± SD. Continuous variables were analyzed using the Student t test, and a χ² test was used to analyze categorical variables. All authors had full access to the data and take full responsibility for their integrity. All authors have read and agreed to the manuscript as written.

Results

Twenty-four patients (age, 38 ± 17 years; men, 17) were included. Twelve patients had slowly conducting accessory pathways and 12 had normally conducting accessory pathways. Pathways were located in the anterospatial region in 6 patients, the midseptal region in 2 patients, and the posteroseptal region in 16 patients.

The mean TCL was 390 ± 80 ms, the AH interval during tachycardia was 151 ± 57 ms, and the VA time was 182 ± 103 ms. A “V–A–V” response after entrainment was observed in all patients. The PPI was 489 ± 102 ms and the StimA interval was 261 ± 133 ms. Table 1 summarizes the characteristics of the tachycardia and response to entrainment.

Table 1. Tachycardia Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Normally Conducting Accessory Pathway</th>
<th>Slowly Conducting Accessory Pathway</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCL, ms</td>
<td>337 ± 44</td>
<td>443 ± 74</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PPI, ms</td>
<td>414 ± 37</td>
<td>563 ± 91</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>VA, ms</td>
<td>96 ± 15</td>
<td>289 ± 74</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>StimA, ms</td>
<td>150 ± 22</td>
<td>371 ± 99</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>AH during tachycardia, ms</td>
<td>202 ± 28</td>
<td>108 ± 34</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PPI–TCL, ms</td>
<td>76 ± 19</td>
<td>120 ± 63</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PPI–TCL &lt;115 ms, n/n</td>
<td>12/12</td>
<td>6/12</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>StimA–VA, ms</td>
<td>55 ± 22</td>
<td>102 ± 63</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>StimA–VA &lt;85 ms, n (%)</td>
<td>12 (100)</td>
<td>6 (50)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD, unless otherwise indicated. PPI indicates postpacing interval; StimA, VA interval measured during pacing; TCL, tachycardia cycle length; VA, ventriculoatrial. P value compares normally conducting and slowly conducting accessory pathways.

Concealed Septal Accessory Pathways

The tachycardia cycle characteristics and response to RV apical entrainment of AVRTs using a slowly conducting concealed septal accessory pathway are described in Table 1. In all patients, the PPI–TCL was <115 ms and the StimA–VA was <85 ms.

Slowly Conducting Concealed Septal Accessory Pathways

The tachycardia cycle characteristics and response to RV apical entrainment of AVRTs using a slowly conducting concealed septal accessory pathway are described in Table 1. In 6 of the 12 patients, the PPI–TCL was >115 ms. In 6 of the 12 patients, the StimA–VA was >85 ms (Figures 2 and 3). There were no tachycardia characteristics that differentiated whether the PPI–TCL would be <115 ms in patients with a slowly conducting accessory pathway (Table 2).

Scanning the cardiac cycle with single premature ventricular contractions during tachycardia was performed successfully in 10 of the patients with slowly conducting accessory pathways. Figure 4 illustrates coupling interval dependence of retrograde conduction in all patients with slowly conducting septal accessory pathways. In all the patients in whom the

Example of entrainment in a slowly conducting concealed septal accessory pathway. In this patient, a His-bundle synchronous ventricular extrastimulus delays the subsequent atrial depolarization, confirming that the tachycardia depends on a decrementally conducting accessory pathway. dcS indicates distal coronary sinus; HRA, high right atrium; pCS, proximal coronary sinus; RVA, right ventricular apex.

![Figure 1. Example of entrainment in a slowly conducting concealed septal accessory pathway. In this patient, a His-bundle synchronous ventricular extrastimulus delays the subsequent atrial depolarization, confirming that the tachycardia depends on a decrementally conducting accessory pathway. dcS indicates distal coronary sinus; HRA, high right atrium; pCS, proximal coronary sinus; RVA, right ventricular apex.](image-url)
entrainment involves at least some acceleration of the cohort with slowly conducting accessory pathways. Because ways but predicted AVNRT in half the patients in this small AVRT in patients with normally conducting accessory path-
ways. Entrainment maneuvers accurately predicted AVRT using slowly conducting concealed septal accessory AVNRT from AVRT cannot be applied with confidence to the calculated PPI during AV reentrant TCL and StimA

Discussion

The major finding of the present study is that the published ventricular entrainment criteria1 for differentiating atypical AVNRT from AVRT cannot be applied with confidence to AVRT using slowly conducting concealed septal accessory pathways. Entrainment maneuvers accurately predicted AVRT in patients with normally conducting accessory pathway but predicted AVNRT in half the patients in this small cohort with slowly conducting accessory pathways. Because entrainment involves at least some acceleration of the tachycardia rate, it is not unexpected that this maneuver might be problematic in such patients. This is not a concern for patients with atypical AV node reentry because any decremental conduction would only prolong intervals further during entrainment, making the conventional cutoff for AVNRT even more robust.

Entrainment should always be performed at rates as close as possible to the tachycardia rate to minimize potential decrement. Nonetheless, it seems prudent to rely on other evidence in patients with slowly conducting retrograde pathways. For example, comparison of pacing and entrainment from the RV apex versus a basal site closer to the septum can be performed while maintaining the same cycle lengths for each site.4 In this instance, shorter intervals from the basal site versus the apex would signal a septal accessory pathway without the confounding effect of rate-dependent prolongation of conduction.

In addition, programming single premature ventricular contractions into the cardiac cycle at the time when the His should be refractory during tachycardia may clearly signal both presence and use of the accessory pathway by delaying subsequent atrial activation in those patients in whom the entrainment criteria were misleading. These data suggest that the traditional ventricular entrainment criteria for the supraventricular tachycardia mechanism will not be reliable for differentiating atypical AVNRT from AVRT using a slowly conducting, decremental retrograde, septal accessory pathway and necessitate other verifying maneuvers.

Table 2. Characteristics of Tachycardias and Patients With Slowly Conducting Accessory Pathways

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>PPI–TCL &lt;115 ms</th>
<th>PPI–TCL &gt;115 ms</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>46±19</td>
<td>50±19</td>
<td>43±20</td>
<td>0.57</td>
</tr>
<tr>
<td>TCL, ms</td>
<td>443±74</td>
<td>446±96</td>
<td>440±51</td>
<td>0.90</td>
</tr>
<tr>
<td>VA, ms</td>
<td>269±74</td>
<td>275±86</td>
<td>264±67</td>
<td>0.81</td>
</tr>
<tr>
<td>VA/TCL, %</td>
<td>60±11</td>
<td>61±12</td>
<td>59±10</td>
<td>0.82</td>
</tr>
<tr>
<td>AH during tachycardia, ms</td>
<td>108±34</td>
<td>111±38</td>
<td>105±33</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Data are presented as mean±SD. No indicators predicted the inability of entrainment criteria to differentiate between septal AV reentrant tachycardia and atypical AV node reentrant tachycardia. Abbreviations as in Table 1.

*P values compare PPI–TCL <115 ms and PPI–TCL >115 ms.
In the present study, we used a VA/R-R cutoff value of 40% to define normally conducting and slowly conducting accessory pathways. We chose this value arbitrarily based on our experience. Although the results of our study would support the use of caution when using entrainment to differentiate atypical AVNRT from AVRT, it is possible that these entrainment criteria are not valid for tachycardias where the VA/R-R is ≤40%.

The present study is limited by relatively small numbers, and as such, the data need to be verified by further observations. Nonetheless, the striking proportion of patients even in this small cohort who provide misleading data with this maneuver makes the observations compelling.

Disclosures

None.

References


CLINICAL PERSPECTIVE

Entrainment of supraventricular tachycardia generally from the right ventricular apex is useful for distinguishing AV node reentry from AV reentry using a septal accessory return pathway. Examination of the postspacing interval and the difference in ventriculoatrial intervals between pacing and tachycardia allow a clear distinction between these 2 possibilities in most individuals. Rate-dependent prolongation of conduction intervals in patients with decremental accessory pathways may reduce the value of these intervals in this context. Accordingly, we tested the validity of this maneuver in patients with AV reentrant tachycardia related to concealed septal accessory pathways both with and without prolonged (defined as ventriculoatrial interval >40% of the tachycardia cycle length) or decremental conduction. Although the maneuver was accurate in normally conducting accessory pathways, it erroneously led to values generally associated with AV node reentry in half the patients with slowly conducting accessory pathways. Consequently, we would conclude that entrainment from the right ventricle in this context is useful if the intervals suggest AV reentry, but additional maneuvers are necessary if the intervals suggest AV node reentry. These maneuvers might include scanning the cardiac cycle during tachycardia with single ventricular cycles or differential ventricular entrainment from basal versus apical right ventricular sites.
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In the article, “Entrainment for distinguishing atypical atrioventricular node reentrant tachycardia from atrioventricular reentrant tachycardia over septal accessory pathways with long right ventricular tachycardia,” by Bennett et al, which appeared in the August issue of the journal (Circ Arrhythm Electrophysiol. 2011;4:506–509), 3 important errors were made.

The title should read, “Entrainment for distinguishing atypical atrioventricular node reentrant tachycardia from atrioventricular reentrant tachycardia over septal accessory pathways with long-RP tachycardia.”

The next to the last author’s name should be spelled Ellaina C. Hogg, BSc.

Also, on page 507, in the 1st paragraph of the Methods, the third line of text now reads: (3) differential ventricular entrainment during tachycardia showed a PPI-TCL that was greater at the RV base than at the RV apex.2–5 This should read: (3) differential ventricular entrainment during tachycardia showed a PPI-TCL that was greater at the RV apex than at the base.2–5

The online version of the article has been corrected.

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