Ventricular Tachycardia due to Reentry in the His-Purkinje System

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Demonstration of Re-entry within the His-Purkinje System in Man

By Masood Akhtar, M.D., Anthony N. Damato, M.D., William P. Batsford, M.D., Jeremy N. Ruskin, M.D., J. Bimbola Ogunkelu, M.D., and Guillermo Vargas, M.D.

SUMMARY

Re-entry within the His-Purkinje system (HPS) was consistently observed in 15/24 consecutive patients in whom retrograde refractory period studies were performed using His bundle electrograms and the ventricular extrastimulus method. Within a narrow range of ventricular coupling intervals (V₁V₂), V₂ retrogradely conducted to the bundle of His (H₂) with significant infra-His bundle conduction delay (V₂H₂ interval). At critical V₂H₂ delays another beat of ventricular origin (V₃) followed V₂ and was associated with H₂V₃ intervals greater than the H-V intervals of sinus beat. It is postulated that V₂ retrogradely blocked within the right bundle branch and activated the bundle of His via the left bundle branch after which antegrade conduction occurred along the right bundle branch producing the V₃ response. In support of re-entry within the HPS are the following: 1) V₃ occurred in a narrow range of V₁V₂ intervals and critical V₂H₂ delays, 2) V₃ did not occur when V₂ retrogradely blocked below the bundle of His, 3) V₃ was independent of retrograde A-V nodal delay, 4) V₃ rarely occurred in patients with pre-existing complete right bundle branch block pattern. These results reasonably exclude local re-entry near the site of stimulation.

Circulation, Volume 50, December 1974
Facilitation of macro-reentry within the His-Purkinje system with abrupt changes in cycle length.  

Denker et al, Circulation 1984
Characteristics of sustained BBR-VT

• Involves *diseased* HPS (*LBBB IVCD, prolonged HV*)
• Significant LV dysfunction
• No scar required
• Induced VT: *LBBB (90%)*
• 6% all induced sustained VT
• *Under-recognized !!!*

_Tchou et al, Circ 1988;  Caceres et al, Circ 1989;  Cohen et al JACC; 1991;  Blanck et al JCE 1993_
Substrate BBR-VT
(92 pts)

- Non-ischemic CMP (53%)

  40% induced VT in CMP are BBR \( (Tchou, 1988) \)

- Ischemic CMP (33%)

- Post-valve replacement surgery (10%)

- HPS conduction delay \( (normal LV function) \)

- Muscular dystrophies \( (Myotonic, Becker) \)
Clinical characteristics BBR-VT (92 pts)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>male 10/1</td>
</tr>
<tr>
<td>Age</td>
<td>62 yrs</td>
</tr>
<tr>
<td>CHF</td>
<td>73%</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>33%</td>
</tr>
<tr>
<td>LVEF</td>
<td>23% (14-65%)</td>
</tr>
</tbody>
</table>
Clinical presentation BBR-VT
(92 pts)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudden cardiac death</td>
<td>25%</td>
</tr>
<tr>
<td>Syncope</td>
<td>55%</td>
</tr>
<tr>
<td>Sustained tachycardia</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>10%</td>
</tr>
</tbody>
</table>
Diagnostic criteria BBR-VT
His-bundle electrogram precedes onset surface QRS.
HV interval is constant, \( = \) or \( > \) than SR HV interval.

Induction depends on critical, retrograde HPS conduction delay.
Appropriate sequence HB, RBB, LBB for the QRS pattern
Appropriate sequence of HPS activation during RBBB-BBR
(Irregular) H-H intervals dictate V-V intervals
BBR-VT with LBBB pattern (92 pts)

- >95% induced with RV stimuli
  
  *(exclusively with short/long cycle lengths in 45%)*

- HV: 80 ms *(same in sinus and VT)*

- Cycle length: 270 ms
BBR-VT with LBBB pattern
BBR-VT with RBBB pattern
(13 pts)

- RV stim (7 pts)
- LV stim (3 pts)
- Pacing during LBBB-VT (3 pts)
- Atrial stim/AFib (3 pts)

- CL: 285 ms
- HV: 130 ms
BBR-VT with RBBB pattern
Facilitation of Sustained Bundle Branch Reentry by Atrial Fibrillation

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University of Wisconsin-Milwaukee Clinical Campus, and St. Luke’s Medical Center, Milwaukee, Wisconsin

Sustained Bundle Branch Reentry. An electrophysiologic evaluation was performed in a patient with an idiopathic dilated cardiomyopathy and syncope. Ventricular tachycardia was not inducible despite the use of a variety of pacing maneuvers during sinus rhythm. Only after the electrical induction of atrial fibrillation did sustained bundle branch reentrant tachycardia (with both right and left bundle branch block QRS configurations) spontaneously occur and become reproducibly induced during right ventricular pacing. Ablation of the right bundle branch eliminated reproducibility of the tachycardia.

Spontaneous BBR-VT with RBBB pattern during rapid AFib
Spontaneous BBR-VT with LBBB during rapid AFib
Reversal of reentrant circuit RBBB to LBBB by pacing during BBR-VT
Ventricular Tachycardia in Valvular Heart Disease
Facilitation of Sustained Bundle Branch Reentry by Valve Surgery

Calambur Narasimhan, MD; Mohammad R. Jazayeri, MD; Jasbir Sra, MD; Anwer Dhala, MD; Michael Biehl, MD; Masood Akhtar, MD; Zalmen Blanck, MD

Circulation, 1997
# Temporal Relationship of Valve Surgery and VT

<table>
<thead>
<tr>
<th></th>
<th>Group: 1</th>
<th></th>
<th>Group: 2</th>
<th></th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early post-op VT</td>
<td>8 / 9</td>
<td></td>
<td>3 / 20</td>
<td></td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>(89%)*</td>
<td></td>
<td></td>
<td>(15%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve surgery to VT</td>
<td>10</td>
<td></td>
<td>72</td>
<td></td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>interval (median)</td>
<td>days</td>
<td></td>
<td>months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* One patient who had VT before surgery had incessant refractory VT soon after surgery.
## Dominant Valve Lesions

<table>
<thead>
<tr>
<th></th>
<th>BBR (n = 9)</th>
<th>Non-BBR (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic stenosis</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Aortic insufficiency</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Mitral insufficiency</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Aortic / mitral</td>
<td>- -</td>
<td>3</td>
</tr>
</tbody>
</table>
## Comparison of Clinical Characteristics Between Patients With BBR-VT & Non-BBR VT

<table>
<thead>
<tr>
<th></th>
<th>BBR (n = 9)</th>
<th>Non-BBR (n = 20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>61 ± 16</td>
<td>64 ± 12</td>
<td>NS</td>
</tr>
<tr>
<td>After valve replacement (No.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVR / aortic valvotomy</td>
<td>7</td>
<td>10</td>
<td>NS</td>
</tr>
<tr>
<td>MVR / mitral valve repair</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>DVR</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>LV ejection fraction</td>
<td>43 ± 19</td>
<td>33 ± 13</td>
<td>NS</td>
</tr>
<tr>
<td>Sudden death / CV collapse</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Syncope / presyncope</td>
<td>3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Palpitations / nonsustained VT</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>CL (ms)</td>
<td>276 ± 46</td>
<td>304 ± 47</td>
<td>NS</td>
</tr>
</tbody>
</table>
Differential Diagnosis of BBR-VT

- Inter-fascicular VT
- Scar-related VT
- Idiopathic VT

- SVT with aberrant conduction
- Atrio-fascicular reentry
• RBB ablation during BBR-VT with RBBB morphology
Catheter ablation of the LBB during BBR-VT
Interfascicular ventricular tachycardia
Incessant Interfascicular Reentrant Ventricular Tachycardia as a Result of Catheter Ablation of the Right Bundle Branch: Case Report and Review of the Literature

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From the Electrophysiology Laboratories of Aurora St. Luke’s and Aurora Sinai Medical Centers, University of Wisconsin School of Medicine and Public Health-Milwaukee Clinical Campus, Milwaukee, Wisconsin, USA

Incessant Interfascicular Ventricular Tachycardia. A 72-year-old woman developed incessant interfascicular (IF) ventricular tachycardia immediately after successful right bundle branch (RBB) catheter ablation for the treatment of sustained bundle branch reentrant tachycardia. Catheter ablation of the left bundle branch and the left anterior fascicle was successful in eliminating the tachycardia (in 2 different sessions). This report discusses the direct link between the creation of an RBB block and the development of IF tachycardia, in our case, and in prior cases of IF reentry reported in the literature. (J Cardiovasc Electrophysiol, Vol. 20, pp. 1279-1283, November 2009)
Interfascicular ventricular tachycardia

I
II
V1
RA
HB
HV = 110 msec.
RV
T
H-H intervals predict V-V intervals
HV interval shortens 40 ms during VT
Interfascicular reentrant ventricular tachycardia (9 pts)

- Immediately post-RBB ablation or preexisting RBBB
- Concomitant BBR-VT
- Shortening HV interval (20-40 ms from sinus HV)
- HPS sequence activation similar to LBBB-BBR
- VT with RBBB configuration
- Requires LBB or fascicular ablation

Blanck et al, JCE 2009
Incessant interfascicular VT after right bundle branch ablation for BBR-VT

Pre-RBB ablation

Post-RBB ablation
sinus rhythm

Post-RBB ablation
RV pacing
Why should you care about diagnosing BBR

- Very fast VT, hemodynamic collapse
- Frequently drug refractory
- Very easy fix
- Avoid extensive scar-related mapping
- More often under-diagnosed
- You are not a general cardiologist!
In summary, to induce BBR-VT:

- Think about BBR-VT!
- Record a His-bundle potential
- Avoid injury to the His-bundle/RBB during initial catheter placement
- Short-long pacing sequences
The end...!