Ablation of Idiopathic Ventricular Tachycardia: Endocardial and Epicardial Approaches

Nitish Badhwar, MD, FACC, FHRS
Associate Chief, Cardiac Electrophysiology
Director, Cardiac Electrophysiology Training Program
University of California, San Francisco

Innovative Procedures, Devices, and State of the Art Care for Arrhythmias, Heart Failure and Structural Heart Disease
October 8, 2015

Disclosures

Honoraria - St. Jude, Biosense, Senterheart
Fellowship Support – Medtronic, St. Jude, Boston Scientific, Biotronik, Biosense Webster

Ventricular Tachycardia

- Non-sustained ventricular tachycardia (NSVT)
  - 3 or more consecutive QRS complexes of ventricular origin at rate of more than 100 bpm
- Sustained VT
  - Lasts more than 30 seconds, usually requires intervention for termination
- Monomorphic VT
  - Uniform QRS configuration
- Polymorphic VT
  - Beat to beat variation in QRS configuration
- Electrical storm
  - > 3 VT/VF episodes in 24 hours
Ventricular Tachycardia

1. Sudden cardiac arrest (ventricular fibrillation)
2. Syncope, near syncope
3. Palpitations with wide complex tachycardia (hemodynamically tolerated) or frequent PVCs

What is the best treatment option?

1. Catheter Ablation
2. Urgent left heart catheterization
3. Start I/V Amiodarone
4. Do Nothing

Wide Complex Tachycardia: Artifact
Idiopathic Ventricular Tachycardia

Polymorphic VT /VF
- Long QT syndrome
- Short QT syndrome
- J wave syndromes - Brugada, Early repolarization
- Catecholamine induced polymorphic VT
- Short coupled torsades

Monomorphic VT
- Outflow tract VT - RVOT VT, LVOT VT, cusp VT
- Fascicular VT - LAF, LPF, Septal
- Annular VT - Mitral, Tricuspid
- VT from crux of heart

Bigeminal PVC

Holter monitor
Independent Predictors of PVC Cardiomyopathy

- Associated with high burden (>24% Holter burden...Bogun et al)
- Monomorphic PVCs
- Cardiomyopathy reverses with ablation of PVC
- Mechanism not well defined
  - ?Coupling interval
  - ?Dysynchrony
  - ?Rate related

Coupling Interval Dispersion and BMI are Independent Predictors of PVC Cardiomyopathy

**Table 3**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.014</td>
<td>0.981–1.043</td>
<td>0.392</td>
</tr>
<tr>
<td>Maximum coupling interval</td>
<td>1.008*</td>
<td>0.997–1.010</td>
<td>0.14</td>
</tr>
<tr>
<td>Coupling interval dispersion</td>
<td>1.045</td>
<td>1.027–1.067</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PVC burden</td>
<td>1.045</td>
<td>1.007–1.089</td>
<td>0.012</td>
</tr>
<tr>
<td>QRS duration</td>
<td>0.992</td>
<td>0.971–1.014</td>
<td>0.992</td>
</tr>
<tr>
<td>Body mass index (&gt; 30 kg/m²)</td>
<td>3.031</td>
<td>1.206–7.681</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Per 1 milliseconds increase in CI.
*Per 1 milliseconds increase in CI-dispersion. BMI = body mass index; CI = confidence interval, SD = standard deviation.

**Figure 4.**

**Right Ventricular Outflow Tract VT (RVOT VT)**

- Electrocardiographic patterns in different leads.
Differentiating ARVC from RVOT

- Lead 1 QRS > 120 ms
- QRS Transition at V5
- Notching QRS complex
- Anterior T wave inversion in sinus rhythm

Left Aortic Cusp VT
Left main coronary artery
Ablation catheter

Left Aortic Cusp VT

Aortic Cusp VT ECG Criteria
- Early transition in precordial leads (V1, V2)
- Notch in V5, lack of S in V5, V6
- Broad R wave and larger R/S in V1, V2
- Variable coupling interval of PVC
- PVC transition compared to sinus rhythm transition
- Phase analysis (as measured from earliest surface onset)
  - Local onset in V2 ≥ 7 ms
  - Initial peak / nadir in III ≥ 120 ms
  - Initial peak / nadir in V2 ≥ 78 ms

Daniels D V et al. Circulation 2006;113:1659-1666

EKG criteria for epicardial VT:
- Precordial MDI
Surgical Epicardial Ablation for Outflow Tract VT

Induction with atrial pacing
- RBBB, LAD
- No structural heart disease (Zipes, 1979)
- Verapamil sensitive (Belhassen, 1981)
- RBBB, RAD (Ohe, 1988)
- Upper septal (Shimoike, 2000)

Outflow Tract VT

Fascicular VT
Left Posterior Fascicular VT


Left Anterior Fascicular VT

Left Ventricular Upper Septal VT
Figure 2. VT morphologies and corresponding circuits in Case 4. (A) Left posterior fascicular VT morphology prior to ablation at outside institution. The circuit includes retrograde conduction up the septal fascicle (S) and antegrade conduction down the posterior fascicle (P), with passive activation of the right bundle branch (RBB) and likely slow conduction down the anterior fascicle (A). (B) VT1 with narrow QRS and right axis deviation. The circuit involves retrograde conduction up S and antegrade conduction down A, with likely block in P. Passive activation of RBB is still present accounting for the narrow QRS. (C) VT2 with RBBB and right axis deviation. The circuit is the same as in B, with either block or significant delay in the RBB accounting for the new RBBB block morphology in comparison to 2B. (D) VT3 with left bundle branch block and left superior axis. The circuit here is bundle branch reentry, with retrograde conduction likely up S and antegrade conduction down RBB.

Sites of Successful Ablation

Empiric or targeted ablation based on entrainment criteria of the mid LPF was initially performed in Cases 1–5 for RBBB LS axis VT. If there was no affect on tachycardia, ablation was extended to the proximal LPF. In all 5 cases, ablation of the LPF terminated RBBB LS axis VT, but resulted in inducible RBBB/narrow complex RI axis VT or RBBB, RI axis. Successful ablation of tachycardia for Cases 1–3 was performed just apical to the LBB, anatomically between the LPF and LAF. In Cases 4 and 5, proximal LAF ablation was performed after LPF ablation, but resulted in LBBB in SR as well as LBBB VT. In Case 4, LBBB VT was proven bundle-to-bundle reentry tachycardia (BBRT) based on all the usual criteria, but with a relatively short HV interval in BBRT (36 milliseconds) versus SR (60 milliseconds) (see “Discussion”). Further ablation in Case 4 was not performed and the patient was placed on medical therapy with Sung RK, et al. JCE. 2013;24:297-304.

Mitral Annular VT

a. Anterolateral
b. Posterior
c. Posteroseptal

Tricuspid Annular PVCs / VT

1. Septal
   a. Qs in V1
   b. Narrower
   c. No notching

2. Lateral
   a. rS in V1
   b. Wider
   c. Notching
Idiopathic VT arising from Cardiac Crux

- Rapid VT, can present as electrical storm
- Exercise induced / require isoproterenol for induction
- Hemodynamic collapse
- Responds to beta-blockers, lidocane
- Catheter ablation is curative

Kawamura M et al. Circ Arrhythm Electrophysiol. 2014 Sep 15 (Epub)

Cardiac Crux

- Cardiac crux is the intersection between the AV, posterior inter-ventricular and inter-atrial grooves

Kawamura M et al. Circ Arrhythm Electrophysiol. 2014 Sep 15 (Epub)

Idiopathic VT arising from Cardiac Crux

Kawamura M et al. Circ Arrhythm Electrophysiol. 2014 Sep 15 (Epub)
Idiopathic VT from Cardiac Crux

**PVC/VT**: QS in lead II and/or III, R > S in lead V2 and MDI \( \geq 0.55 \)

- LBBB pattern
- R < S in lead V6
  - YES
  - Basal crux-VA
  - NO
  - Apical crux-VA
  - Middle MCV mapping
  - 1) Proximal-CS mapping
  - 2) Proximal MCV mapping
  - LV posterolateral mapping
  - Epicardial surface mapping using subxiphoid approach

RBBB pattern

- R < S in lead V6
  - Apical crux-VA
  - Basal crux-VA
  - Middle MCV mapping
  - 1) Proximal-CS mapping
  - 2) Proximal MCV mapping
  - LV posterolateral mapping
  - Epicardial surface mapping using subxiphoid approach

Idiopathic RBBB LAD VT

- **Fascicular VT**
  - rS in II, III, avF
  - MDI <0.55
- **Papillary muscle VT**
  - Can have QS in II, III, qR in V1, QRS >150 ms
  - Rarely MDI > 0.55
- **Crux VT**
  - QS in II, III
  - QS or r/S in V6, R in avR, MDI >0.55
Exercise Induced Ventricular Tachycardia

Pace map

Successful Epicardial Site of Ablation

Idiopathic monomorphic VT usually arises from outflow tract, fascicles, annulus or Crux and can be epicardial in origin. ECG characteristics can localize the site of origin of VT and guide catheter ablation. Treatment:
- Monomorphic VT / Frequent PVCs curable with catheter ablation
- Polymorphic VT treated with ICD and drugs

Outflow tract VT can arise along the course of AIV, GCV, LAD. Epicardial VT arising from the crux along the course of MCV. Uncommon origin along the lateral LV (remote from vascular structures). Excellent response to epicardial ablation.