Ventricular Tachycardia: Catheter Ablation
When? How?

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  – Abiomed Inc, Biosense-Webster Inc, Stereotaxis Inc, St Jude Medical Inc

• I will be discussing off-label use of catheter ablation devices.
Outline

- Post-MI VT Ablation
  - Is there a mortality benefit?
- Other Scar-VT substrates
- Outflow-Tract VT/PVCs
Outline

• Post-MI VT Ablation
  – Is there a mortality benefit?

• Other Scar-VT substrates

• Outflow-Tract VT/PVCs
Pathogenesis of Scar-Related VT

- Electrically-active live myocardial fibrils traversing through the fibrotic tissue of the scar
Post-MI VT: Catheter Ablation

- Post-MI VT is not a simple substrate with a single circuit
- Better to think of post-MI VT as an arrhythmogenic mass of tissue from which multiple VTs can emanate
- For clinical success need to treat not as circuits but as substrate

Downar et al, *JACC* 1998
Substrate Mapping & Ablation

1. Target Channels for Ablation
2. Target VT Exit Sites
Catheter Ablation of Post-MI VT

• Sole Therapy (EF > 40%, Stable VT)

• Adjuvant Therapy to ICD Implantation
  – Slow VT (below ICD rate cutoff)
  – ICD shocks
    • Hemodynamically-stable VT
    • Hemodynamically-unstable VT

• “Primary” Prevention of ICD shocks
Catheter Ablation of Post-MI VT

- **Sole Therapy** (EF > 40%, Stable VT)
  
- **Adjuvant Therapy to ICD Implantation**
  - Slow VT (below ICD rate cutoff)
  - ICD shocks
    - Hemodynamically-stable VT
    - Hemodynamically-unstable VT

- **“Primary” Prevention of ICD shocks**
Substrate Ablation of Unstable VT

VT Ablation: Multicenter Outcome

Stevenson at al, *Circulation* 2009
Catheter Ablation of Post-MI VT

• Sole Therapy (EF > 40%, Stable VT)

• Adjuvant Therapy to ICD Implantation
  – Slow VT (below ICD rate cutoff)
  – ICD shocks
    • Hemodynamically-stable VT
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• “Primary” Prevention of ICD shocks
Preventative substrate ablation in preventing ICD shocks in post-MI pts who have sustained a VT/VF event (ie, 2° prevention ICD pts)

- History of a MI Cardiac Arrest (VT/VF)
- Randomization
  - ICD
  - ICD + Substrate Ablation
- Follow-Up (2 years)

Can catheter ablation reduce VT/VF in post-MI patients undergoing ICD implantation for stable VT?

History of a MI  
Stable VT  
LVEF < 50%

Randomization

ICD  
ICD + Ablation

Follow-Up (2 years)

Outline

• Post-MI VT Ablation  
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• Outflow-Tract VT/PVCs
Results of VT Ablation
Effect of Acute Inducibility: VT Recurrence

- 528 scar-VT patients treated with ablation
- Results of programmed stimulation:
  - Class A (Non-inducibility of any VT) → 77%
  - Class B (Inducibility of “non-clinical” VT) → 12.4%
  - Class C (Inducibility of “clinical” VT) → 10.6%

Mortality After VT Ablation
Large Single-Center Experience

- 518 pts undergoing first-ever scar-VT ablation
- Acute failure (unable to ablate clinical VT) in 52 pts (10%)
  - Predictor of VT recurrence: HR=2.4, p<0.001
  - Predictor of Mortality: HR=2.0, p=0.004

Tokuda M et al, JAHA doi: 10.1161/JAHA.113.000072 (2013)
Mortality After VT Ablation
Comparison to Non-Ablated Patients

- 102 consecutive pts undergoing scar-VT ablation
- 817 patients with ICDs and a history of appropriate shocks
- 2,088 patients with ICDs and no history of appropriate shocks

Outline

• Post-MI VT Ablation
  – Is there a mortality benefit?

• Other Scar-VT substrates

• Outflow-Tract VT/PVCs
The Difficult VT Ablation

- Epicardial Ablation
- Deep (Septal) Circuits
  - Hemodynamic Support
  - Bipolar RF
  - EtOH Ablation
- Neuraxial Modulation

- Post-MI (~10%)
- Other VT Substrates
  - DCM
  - Chagas-Related
  - Sarcoidosis
  - HCM
  - ARVC
The Difficult VT Ablation

- Epicardial Ablation
- Deep (Septal) Circuits
  - Hemodynamic Support
  - EtOH Ablation
  - Bipolar RF
- Neuraxial Modulation

Modified from slide from: E Sosa, M Scanavacca, A d’Avila
The Difficult VT Ablation

- Epicardial Ablation
- Deep (Septal) Circuits
  - Hemodynamic Support
  - EtOH Ablation
  - Bipolar RF
- Neuraxial Modulation
Sarcoid & HCM VT Ablation

ARVC-Related VT

Ventricular Epicardium


Reddy & Wilber, Manuscript Submitted
ARVC-Related VT Ablation

**Endo Ablation**

![Graph showing percent free of recurrence over time since procedure (years) for Endo Ablation]

- **Event / At risk**
  - 29/47
  - 8/15
  - 2/5
  - 1/3
  - 0/2

**Epi/Endo Ablation**

- **17 Patients**
- **Mean f/u: 49 ± 21 mo**
- **Success rate: 88%**

![Graph showing percent free of recurrence over time since procedure (years) for Epi/Endo Ablation]

- **Event / At risk**
  - 1/17
  - 0/14
  - 1/13
  - 0/11
  - 0/8

*Dalal et al JACC 50:432, 2007.*

*Reddy & Wilber, Manuscript Submitted*
The Difficult VT Ablation

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Mostly Intramural Scar: What do you do?
Bipolar Ablation

Clinical Case Example

Lee et al, *PACE* (2011)
The Difficult VT Ablation

- Epicardial Ablation
- Deep (Septal) Circuits
  - Hemodynamic Support
  - Bipolar RF
  - EtOH Ablation
- Neuraxial Modulation
Case – DCM-VT: Deep Septal VTs

16 seconds to terminate

RFA

VT Recurred Two Days Later...

2nd Procedure
The Difficult VT Ablation

- Epicardial Ablation
- Deep (Septal) Circuits
  - Hemodynamic Support
  - EtOH Ablation
  - Bipolar RF
- Neuraxial Modulation
  - Renal Denervation
  - Stellate Ganglionectomy

Outline

• Post-MI VT Ablation
  – Is there a mortality benefit?
• Other Scar-VT substrates
• Outflow-Tract VT/PVCs
Outflow-Tract VT

- Structurally-normal heart
- RVOT- or LVOT-VT
- ECG:
  - LBBB
  - Positive QRS in II / III / aVF
  - QRS transition V3/V4
    - Early transition → LVOT
    - Can be RBBB
- Not life-threatening
  - [rare exceptions]
45 yo Fireman with OTVT → ICD

ICD Interrogation
RVOT VT Ablation
The Difficult Outflow-Tract VT

- LVOT
- Aortic Valve Cusps
- Great Cardiac Vein
- Base of LAA
- Epicardial
- Prox Pulmonary Artery

Obel et al., JACC 48:1813, 2007

What about PVCs?
Canine Model

Bigeminal PVC Pacing vs Control

PVC Burden and LV Function


- **Sensitivity**: 79%
- **Specificity**: 78%

43/57: PVC > 24%

25/117 with Normal EF with PVC > 24%

57pts: 81% had > 80% PVC reduction

- **14/57: PVC < 24%**
- **Burden**: 10 – 21%

n = 174 pts
Effect of PVC Ablation
Prospective 4-Center Study

- 80 Consecutive pts referred for PVC ablation
- Other structural heart disease in 27 (34%) – mostly Ischemic HD

Penela et al, JACC, 62:1195 (2013)
Effect of PVC Ablation
Prospective 4-Center Study

- 13% baseline PVC burden: 100% Sens / 85% Specificity to predict an absolute LVEF increase of 5% after catheter ablation
- 20 patients with Class I ICD indication no longer eligible at 6 months post-ablation.

*Penela et al, JACC, 62:1195 (2013)*
• 65 CRT Non-Responders with >10,000 PVCs/24h undergoing ablation
• Age 66.6, 78% male, QRS duration = 155 ± 18 msec
• Acute and 12-mo success of ablation: 91% and 88%
• Improvements in LVEF (26.2 → 32.7%, p < 0.001), LVESD, LVEDD, LVESV, LVEDV, NYHA (3.0 to 2.0, p < 0.001)

Lakkireddy et al, JACC 60:1531 (2012)
Predictors of PVC-Cardiomyopathy

Interpolated PVCs

<table>
<thead>
<tr>
<th></th>
<th>Patients with CMP</th>
<th>Patients without CMP</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>21</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>50 ± 15</td>
<td>47 ± 16</td>
<td>.5</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>14/7</td>
<td>18/12</td>
<td>.8</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>37 ± 10</td>
<td>59 ± 7</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>PVC burden (%)</td>
<td>30 ± 11</td>
<td>14 ± 15</td>
<td>.0001</td>
</tr>
<tr>
<td>Interpolation, n (%)</td>
<td>14 (67)</td>
<td>6 (20)</td>
<td>.001</td>
</tr>
<tr>
<td>Interpolation burden (%)</td>
<td>21 ± 30</td>
<td>4 ± 13</td>
<td>.008</td>
</tr>
</tbody>
</table>

Ogün et al, *Heart Rhythm* 8:1046 (2011)
Predictors of PVC-Cardiomyopathy
Long-Duration Symptoms & Asymptomatic

<table>
<thead>
<tr>
<th>Clinical characteristics</th>
<th>Adjusted odds ratio</th>
<th>95% confidence interval</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic status</td>
<td>13.1</td>
<td>4.1–37.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Duration of palpitations (mo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>1.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>30–60</td>
<td>4.0</td>
<td>1.1–14.4</td>
<td>.03</td>
</tr>
<tr>
<td>&gt;60</td>
<td>20.1</td>
<td>6.3–64.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PVC burden in asymptomatic patients*</td>
<td>2.1</td>
<td>1.2–3.6</td>
<td>.007</td>
</tr>
</tbody>
</table>

PVC, premature ventricular complex.
*PVC burden centered at the average value of 19% and divided by 10, and so a 1-unit increase corresponds to a 10% increase in PVC burden.

Predictors of PVC-Cardiomyopathy

**QRS Width**

- **ROC Analysis:** QRS >150ms best predicts development of CM
  - Sensitivity = 80%; Specificity = 52%

<table>
<thead>
<tr>
<th>Variables</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC burden</td>
<td>1.04*</td>
<td>1.01/1.08</td>
<td>.02</td>
</tr>
<tr>
<td>QRS width</td>
<td>1.03†</td>
<td>1.0/1.05</td>
<td>.03</td>
</tr>
<tr>
<td>Epicardial origin of PVC</td>
<td>2.9</td>
<td>1.01/7.8</td>
<td>.04</td>
</tr>
<tr>
<td>Symptom duration</td>
<td>1.005‡</td>
<td>1.18/2.33</td>
<td>.002</td>
</tr>
<tr>
<td>Sex: Man</td>
<td>0.7</td>
<td>0.4/1.77</td>
<td>.5</td>
</tr>
</tbody>
</table>

CI = confidence interval; PVC = premature ventricular complex.

*Per 1% increase in PVC burden.
†Per ms increase in QRS width.
‡Per 1-month increase in symptom duration.

PVC-Cardiomyopathy
Recovery of LV Function After Ablation

- EF normalized at a mean of 5 ± 6 mo
- LVEF Recovery within 4 mo in 68%
- In remaining, Recovery at 12 ± 9 mo (range 5 – 45 mo)
- QRS width longer in delayed recovery (170 vs 159, p= 0.02)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Odd ratio (95% confidence interval)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>QRS width</td>
<td>1.04 (0.97–1.10)</td>
<td>.27</td>
</tr>
<tr>
<td>PVC burden preablation</td>
<td>1.04 (0.97–1.12)</td>
<td>.27</td>
</tr>
<tr>
<td>Right bundle branch block</td>
<td>1.16 (0.20–6.75)</td>
<td>.87</td>
</tr>
<tr>
<td>morphology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RVOT origin</td>
<td>0.42 (0.04–4.84)</td>
<td>.48</td>
</tr>
<tr>
<td>Epicardial origin</td>
<td>11.1 (1.42–86.8)</td>
<td>.02</td>
</tr>
</tbody>
</table>

Final Thoughts

• **Scar-Related VT:**
  – Can safely eliminate scar-related VT
  – VT Ablation can be complicated ➔ Need to be prepared (Epicardial Ablation, Alcohol ablation, Hemodynamic Support, Neuraxial Modulation)
  – Non-MI Patients (Epi important)
    • ARVC-VT Ablation: Excellent Outcome

• **Outflow-Tract VT**
  – Recognize it! ➔ ICDs are not indicated
  – PVCs – When to intervene?
    • Symptoms
    • Ventricular Dysfunction / Dilatation
    • High burden??