Mapping of Ventricular Tachycardia
Coronary Artery Disease:
Does Entrainment Have a Role in the Era of Substrate Modification?

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~ Disclosures ~
Medtronic, Inc. (Research & training support; Consultant; Lecturer)
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Stereotaxis, Inc.; Topera Medical (Advisor Board)

What Are We Talking About?

Typical patient with scar-related VT
• Substantial scar burden
• Decreased ventricular systolic function
• Comorbidities (PVD, COPD, etc.)
• ICD present
• Many have had prior cardiac surgery (CABG, valve)
• Already taking amiodarone in varying dose

What’s “Classical/Entrainment Mapping”?

Classical mapping = activation mapping
• Acquiring timing of local electrograms looking for “earliest” activation (macroreentry: mid-diastolic)
• May be used with or without mapping system
• Endpoint is termination of VT and non-inducibility

Entrainment mapping -
• Assessing presence of concealed fusion during and PPI or PPI-TCL after pacing at candidate sites
• Sites with (PPI – TCL) < 30 ms are likely in circuit
• Generally requires mapping system
• Endpoint is termination of VT and non-inducibility

What Are We Talking About?

Ideal procedure for ablation in scar-related VT
• Readily performed in most patients
  ▪ Few procedural constraints
    – Can apply in wide range of patients – heart failure
  ▪ Equipment/skills universally available
    – No special electrodes/systems/analytical skills
  ▪ Achievable endpoints
    – Measurable outcomes
• Good outcomes
  ▪ Safety
    – Acute survival, freedom from complications
  ▪ Efficacy
    – Freedom from recurrent VT episodes off antiarrhythmic drugs
    – Survival
Entrainment Criteria

Entrainment essentials:
• Start with stable tachycardia
• Overdrive pace till all relevant electrograms are accelerated to paced cycle length
• After cessation of pacing, same tachycardia resumes
• Fusion is present during pacing

Determining presence of fusion:
• Know what pure pacing looks like (dissimilar from both tachycardia and pacing during tachycardia)
  ▪ Have an example of pure pacing (during sinus rhythm)
  ▪ Know what pure pacing *should* look like
• Show graded change in activation at different paced rates (“progressive fusion”)
• Observe stimulus artifact after onset of accelerated complex

Classical/Entrainment Mapping

Advantages –
• Familiarity
• Assurance we are in the right spot (not bystander)
• Proof of concept – RF terminates VT

Disadvantages –
• Irregular tachycardias - bad news, good news
• No inducible stable tachycardia
• Difficult interpretation of post-pacing electrograms
• Cycle length-dependent conduction slowing
• Rarely, best ablation site is systolic (within QRS)
• Multiple tachycardias - spontaneous/induced change

Spontaneous Onset at Suspicious Site

3:11 PM

Entrainment at Site

3:12 PM
Ablation at Site

3:20 PM

Substrate Mapping

- Acquire voltage/location data to determine location of:
  - Barriers to/boundaries for conduction (valve annuli, scar)
  - Channels of conduction between barriers
  - Late potentials
  - Sites with pacemaps similar to known VT morphologies

- Advantages:
  - Treats current VTs, may preclude future arrhythmias
  - Don’t have to have inducible/mappable tachycardia
  - Don’t have to know how to do the other stuff

- Disadvantages:
  - Takes time and dense mapping
  - Lots of ablation; possible volume overload/collateral damage
  - Accuracy (false positive “scar”)

Substrate-Based Ablation

Several techniques have been applied –
- Encircle scar region
- Radial lines through border zone
- Transect conduction channels
- Render sites of pacemapping non-capturable
- Effect block across ablation line (mitral isthmus)
- Elimination of late potentials
- Scar homogenization

Apical Scar Delineated
Connecting Barriers to Transect Circuit(s)

Lesion Set Based on Scar

Radial Array

Late Potential Elimination
Voltage Mapping

Elimination of Late Potentials with Ablation

Pre-Ablation

Post-Ablation

Late Potential Distribution

Voltage Mapping: Specificity

Baseline Voltage Map

Edited Voltage Map
Endpoints of Ablation

What is the best endpoint of ablation?

- Inducibility-based
  - Non-inducibility of clinical VT
  - Non-inducibility of mappable VT
    - What is “mappable” vs not varies widely among centers
  - Non-inducibility of all VTs
    - Hard to achieve in amiodarized patients
- Substrate-based
  - Elimination of late potentials
  - Rendering areas non-capturable
  - Completion of lesion set
  - Demonstration of block on a line (e.g., mitral isthmus)
  - Homogenization of scar (“seeing red”)

Mapping Techniques Compared

<table>
<thead>
<tr>
<th>Requires sustained tachycardia</th>
<th>Requires CL stability</th>
<th>Requires mapping system (computer)</th>
<th>Usable in sinus rhythm</th>
<th>Sensitive</th>
<th>Specific</th>
<th>Ability to preempt future arrhythmias</th>
<th>Extent of ablation</th>
<th>Potential for CHF (fluid; collateral damage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>++</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+++</td>
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Entrainment vs Substrate Mapping

Summary –

- Activation and entrainment mapping are powerful tools in treatment of scar-related VTs
  - Proof of being at the correct ablation site
  - Reasonable endpoints and outcomes
  - While these are potent tools, they have wrinkles
    - Irregular VT; changing VTs; no inducible VT/unstable VT
- Substrate mapping is also an excellent tool
  - Can be used in all patients
  - Reasonable endpoints and outcomes
  - Not a perfect tool
    - Relatively low sensitivity and specificity
    - Substantial time used, volume administered
**Approach to Scar-Based VT**

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**Entrainment vs Substrate Mapping**

**Conclusions –**

- Activation/entrainment *and* substrate mapping are both very valuable tools for treatment of scar-related ventricular tachycardias
  - There will be cases in which one or the other is not practical or proves unreliable
  - It is important for the practicing electrophysiologist to be facile with both techniques
- These should be regarded as complimentary, rather than “this or that” tools