How to Ablate Atrial Tachycardia
Mechanisms and Approach

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Contents

• Mechanisms of focal atrial tachycardia
• Various mapping techniques
• Detailed discussion on activation sequence mapping and entrainment mapping
Clinical features

• Paroxysmal (non-sustained)
• Atrial rate 130-250 bpm
• Isoelectric segment
• With or without structural heart disease

Focal source
Mechanisms

- Abnormal automaticity
- Triggered activity
- Micro-reentry
- Macro-reentry

Kalman: Circ 93:502, 1996
Determination of Site of origin of AT
Using 12 lead ECG

Tang et al JACC 1995
Pitfalls

- Chamber enlargement / displacement
- Pulmonary disease
- Presence of scars
- Reentrant tachycardia – tell the exit site only
- *Be prepare of mapping the opposite chamber!*
<table>
<thead>
<tr>
<th></th>
<th>Automaticity</th>
<th>DAD-Triggered Activity</th>
<th>Reentry</th>
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<tbody>
<tr>
<td><strong>Initiation</strong></td>
<td></td>
<td></td>
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<tr>
<td>- <em>RVP</em></td>
<td>-</td>
<td>+</td>
<td>+</td>
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<tr>
<td>- <em>PES</em></td>
<td>-</td>
<td>±</td>
<td>+</td>
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<tr>
<td>- <em>Catecholamines</em></td>
<td>+</td>
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<tr>
<td><strong>Termination</strong></td>
<td></td>
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<tr>
<td>- <em>RVP</em></td>
<td>-</td>
<td>±</td>
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<tr>
<td>- <em>PES</em></td>
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<td>+</td>
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<tr>
<td>Reproducibility</td>
<td>-</td>
<td>±</td>
<td>+</td>
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<tr>
<td><strong>Response to Ventricular Extrastimuli</strong></td>
<td>Resetting with flat response</td>
<td>Resetting with flat Response / decreasing Response</td>
<td>Resetting with flat response / increasing Response / mixed Response</td>
</tr>
<tr>
<td><strong>Response to Overdrive Pacing</strong></td>
<td>Suppression</td>
<td>Acceleration / Termination</td>
<td><strong>Entrainment / Termination</strong></td>
</tr>
<tr>
<td><strong>Post-Pacing Interval</strong></td>
<td>Increased with pacing CL &amp; duration / proximity of pacing site</td>
<td>Decreased with pacing CL ± CI of extrastimuli</td>
<td>Increased with pacing CL / CI of extrastimuli</td>
</tr>
</tbody>
</table>
Mapping Techniques

• Activation Sequence mapping
  – Delineate the sequence (timing) of activation at each point for the whole cardiac chamber

• Entrainment Mapping
  – Delineate a reentrant circuit
Mapping Techniques

• **Substrate mapping**
  - Delineate the area of ‘scar’
  - Bipolar EGM voltage <0.05-0.1mV

• **Pacemapping**
  - Reproduce the ‘morphology’ of the tachycardia by pacing
  - P wave morphology / intracardiac EGM activation sequence
  - Uncommonly used
Focal Tachycardia

- Excitation wavefront propagates away from a focus to depolarize the reminder of cardiac chambers
- Activation Sequence mapping to define the earliest activation site
- Mapping of the entire cardiac chamber accounts for <50% TCL
- Ablate the earliest activation site relative to the onset of surface P wave (usually ~20-40 ms ahead)
Reentrant Tachycardia

- Tachycardia resulted from a self-propagating circuit
- **Activation mapping** delineates the sequence of depolarization
- Mapping of the entire circuit accounts for the TCL
- **Substrate mapping** to help define the circuit
- **Entrainment mapping** to determine the critical isthmus
Reentrant Tachycardia

- Ablate the critical isthmus
- Ablation line anchors to electrically inactive structures
- Bidirectional block

Kalman: Circ 93:502, 1996
Delineate mechanism first or do the mapping first?

- Mechanism first
  - You know what to map and what to expect
  - Appropriate use of mapping techniques
- Mapping first
  - Pacing may terminate or change the tachycardia
  - Hx and mode of induction may give you a clue
- Depends on whether the tachycardia is difficult to induce or sustain
Example
- Focal atrial tachycardia
Activation Sequence Mapping

• Find the onset of activation at each point in the cardiac chamber

• Color-coded on 3D mapping system
Crista tachycardia

Focus of AT

Posterior

Anterior

IVC

TVA
EGM Annotation

• Bipolar
  – Earliest: least desirable
  – Peak amplitude: far-field
  – 1st peak: Issue with double potential
  – Earliest near-field deflection

• Unipolar
  – Rapid downstroke (fastest dV/dt)

Ref Bipolar

Unipolar

Del Carpio Munoz 2011
Choice of Window

- **Surface P wave**
  - Obscured
  - Neither ‘max’ or ‘min’

- **CS Catheter**
  - Subtle movement
  - Not in line with the onset of surface P wave

- **Screwed in RA catheter**
$40 + 60 = 100$
Choice of Window

CL = 300 ms
Before: 90-100 ms
After: 180-200 ms
21 msec
Example
- Reentrant atrial tachycardia
Activation Sequence mapping
Classical Example – Typical Atrial Flutter
Choice of Window

- 90-100% TCL
- Colors depend on choice of window
- Incomplete CL:
  - Incomplete anatomic definition
  - Wrong chamber
  - Missing chamber
  - Anatomical variation
  - Wrong mechanism
  - Fragmentations

Del Carpio Munoz et al, 2011
What is entrainment mapping?
Entrainment

- Entrainment is the continuous resetting of a reentry circuit
- Ventricular stimulus enters the circuit through the excitable gap
- Orthodromic wavefront propagates throughout the circuit
- Antidromic wavefront collides with previous wavefront
Criteria for entrainment

- **Constant fusion** except for the **last paced beat which is entrained not fused**
  - Manifested fusion
  - Concealed fusion (Protected area – isthmus; inner loop; bystanders)

- **Progressive fusion**

- Localized **conduction block** to a site for 1 paced beat that is associated with interruption of the tachycardia is followed by activation of that site by the next paced beat from a **different direction** and with a **shorter conduction time**

N+1th pacing beat (P) fuses with Nth entrained beat (E) !!!
Localization of the circuit – what we learned from VT

- Find the circuit
- Find the exit
- Find the isthmus
- Find the entrance

- **PPI-TCL**
  - $<20-30 \text{ ms}$

- **S-QRS or EGM-QRS / TCL**
  - $<0.3; 0.3 - 0.7; > 0.7$
Localization of the circuit – PPI - TCL

- Find the circuit
- **PPI-TCL**
  - The farther the pacing site is from the circuit, the longer the PPI - TCL
Example - Manifested Entrainment
Entrainment mapping
Classical Example – Typical Atrial Flutter

Delacretaz et al, 2001
Activation map vs PPI Map

Santucci et al, 2009
Relevance to our topic
- Microreentrant Tachycardia
- M/64
- PHx of lone atrial fibrillation with CPVI done
- Recurrent atrial tachycardia 2 years post ablation
- Refractory to medical therapy
CL = 265 ms
265 – 27 – 104 = 134 ms
What will you do?

- Decide that this is a focal tachycardia and ablate there?
- Map the opposite chamber?
- Map the RA?
- Further mapping?
Fragmented bipolar signals

- Existence of slow conduction area
- Viable tissue within scar / diseased myocardium
- Setting up of reentrant circuit
265 – 27 – 104 = 134 ms

140 msec
• Ablation terminates tachycardia
• No longer inducible
• A slow zone resulted from previous ablation caused microreentrant tachycardia
Summary

• Focal atrial tachycardia can be resulted from automaticity, triggered activity or reentry
• Appropriate use of mapping techniques include activation sequence, entrainment, substrate, and pacemapping
• Understands the potential pitfalls from ECG interpretations to mapping techniques