Localization of Atypical Atrial Flutter

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Things to consider in Atypical AFL mapping

Index ablation lesion sets?
How to localize the atypical flutter

❖ ECG characteristics

❖ Activation pattern
  using multipolar catheters in both chambers

❖ Cycle length variation: spontaneous or by pacing
  leading chamber vs passive chamber

❖ Overdrive pacing
  ✓ PPI with entrainment
  ✓ Number need to entrain
  ✓ NNE difference between chambers
How to localize the atypical flutter

- **ECG characteristics**
- **Activation pattern**
  using multipolar catheters in both chambers
- **Cycle length variation**: spontaneous or by pacing
  leading chamber vs passive chamber
- **Overdrive pacing**
  - PPI with entrainment
  - Number need to entrain
  - NNE difference between chambers
Seeking the useful ECG characteristics for identifying the AT mechanism

196 ATs with visible P waves: Macoreentry 57%, Focal 43%

Saw-tooth pattern in peritricuspid AT: 27%

Isoelectric line > 80msec: focal 47%, macroreentry 24%
Useful Electrocardiographic Features to Help Identify the Mechanism of AT Occurring After Persistent AF ablation

1. Negative P wave in V1 → Right atrial origin

2. «Precordial transition» → Counterclockwise Peritricuspid AT

**Precordial Transition**: a gradual transition from an **upright component in lead V1** to a **negative component with progression** across the precordium: **sensitivity, 59% ; specificity, 98%**
Useful Electrocardiographic Features to Help Identify the Mechanism of AT Occurring After Persistent AF ablation

3. Negative, or negative-positive, P wave in any of the leads V2-V6 in the absence of a «precordial transition»

Presence of a negative or negative-positive P-wave in any of leads V2 to V6: 30% sensitivity & 97% specificity

4. Negative “notched” component at the beginning of a positive P wave in the inferior leads

“notched” negative component at the beginning of a positive P-wave in the inferior leads: 25% sensitivity & 98% specificity
CS activation and ECG characteristics of roof-dependent LA flutter after pulmonary vein isolation

MA activation time (from the earliest to the latest signal on decapolar CS catheter)

- ≤ 39 msec and non-sequential
  - Sensitivity 100% and a Specificity 97%
  - Must Exclude CTI flutter

- > 39 msec and sequential
  - Roof flutter
    - p wave in the inferior leads
      - positive
        - PA roof atrial flutter
      - negative
        - AP roof atrial flutter

  - Mitral isthmus flutter
    - p wave in the inferior leads
      - negative
        - CW mitral annular flutter
      - positive
        - CCW mitral annular flutter
      - negative and distal to proximal CS activation
      - positive and proximal to distal CS activation
How to localize the atypical flutter

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Mapping of atrial tachycardias after catheter ablation for atrial fibrillation: Use of bi-atrial activation patterns to facilitate recognition of origin

Coronary sinus activation

CS dis-prox (pattern I-III)

RA activation

low-high uniform with CS

Lateral LA (pattern I)

CS prox-dis (pattern IV-VII)

RA activation

high-low after proximal CS

Lateral LA with CTI block (pattern II)

high-low preceding proximal CS

Roof via Bachmann’s bundle (pattern III)

RA (pattern IV)

Septal/roof with CTI block (pattern V)

Septal/roof (pattern VI)

Lateral LA with MA line block (pattern VII)

low-high after CS

low-high after proximal CS

low-high timing with CS

low-high after CS
Tachycardia intracardiac EGM

1
F
V1
HRA-p
HRA-d
His-p
His-d
CS-p
CS-d
Tachycardia intracardiac EGM
How to localize the atypical flutter

- ECG characteristics
- Activation pattern using multipolar catheters in both chambers
- **Cycle length variation**: spontaneous or by pacing leading chamber vs passive chamber
- Overdrive pacing
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  - NNE difference between chambers
Overdrive Pacing @ CS 1-2 with PCL 230 msec

1 2 3
V1 V6
His-p
His-d
TA19-20

TA1-2
CS-p
CS-d

0.4 s
How to localize the atypical flutter

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  - NNE difference between chambers
A Novel Pacing Maneuver to Localize Focal Atrial Tachycardia

- Cannot be entrained so meaning of the PPI is different
- **PPI-TCL** was *proportional to the distance from the AT focus*
- It *helps to localize the origin* of atrial tachycardia
Entrainment mapping for rapid distinction of left and right atrial tachycardias

- After confirming the tachycardia is macroreentry
Overdrive pacing during tachycardia

Possible responses to overdrive pacing

- **No capture!!**
- **Entrainment**
- **Changes in tachycardia**
  - Change to a different circuit
  - Change to a different exit from the same circuit
  - Acceleration
- **Termination**
Overdrive pacing during tachycardia

Sometimes the PPI is difficult to interpret

- Can’t see electrogram
  - Blown out by stimulus strength
  - Very low amplitude

- Conduction delay in slow conduction area

- Irregular tachycardia cycle lengths
Derivation cohort: 10 typical atrial flutter
Validation cohort: 30 patients, 76 IARTs
Definition of Number need to entrain (\textit{NNE}) from the 1\textsuperscript{st} stimulus to the stimulus that accelerates EGMs @ both LRA & LCS to the PCL

\textit{if it was appropriately timed}
Number Needed to Entrain
A New Criterion for Entrainment Mapping in Patients With Intra-Atrial Reentrant Tachycardia

- NNE highly correlated with the PPI – TCL ($r = 0.906; P < 0.001$)
- $NNE \leq 2$ predicted a $PPI – TCL \leq 20 \text{ ms}$
- NNE remained valid in 36 (11%) entrainment attempts, which was changed or terminated

<table>
<thead>
<tr>
<th>TCL–PCL</th>
<th>n</th>
<th>AUC</th>
<th>NNE Cut-Off</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
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<tbody>
<tr>
<td>5–15 ms</td>
<td>121</td>
<td>0.920</td>
<td>$\leq 2$</td>
<td>47</td>
<td>98</td>
<td>88</td>
<td>85</td>
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<td></td>
<td></td>
<td></td>
<td>$\leq 3$</td>
<td>90</td>
<td>92</td>
<td>79</td>
<td>97</td>
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<td></td>
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<td>$\leq 4$</td>
<td>100</td>
<td>81</td>
<td>64</td>
<td>100</td>
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<td>16–30 ms</td>
<td>131</td>
<td>0.989</td>
<td>$\leq 2$</td>
<td>84</td>
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<td></td>
<td></td>
<td>$\leq 3$</td>
<td>100</td>
<td>86</td>
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<tr>
<td>31–50 ms</td>
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<td>$\leq 2$</td>
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<td>87</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$\leq 3$</td>
<td>100</td>
<td>70</td>
<td>46</td>
<td>100</td>
</tr>
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AUC indicates area under the receiver operating characteristic curve; NNE, number of pacing stimuli needed to entrain; NPV, negative predictive value; PCL, pacing cycle length; PPV, positive predictive value; and TCL, tachycardia cycle length.
Overdrive pacing technique

- Start with *stable tachycardia*
- Decide the *chamber to pace first*
- *Synchronization* at the pacing site
- Overdrive pacing at a fixed rate *slightly faster (10~30 msec)* than tachycardia for several cycles
- Overdrive pace until *all relevant electrograms are accelerated to paced cycle length*
- Assess the response to overdrive pacing
- *Find the target and validate it*
35 yo man with myxomatous mitral valve
- Underwent valve repair + maze 2013
- Underwent ablation of “focal right atrial tachycardia” 2014
- Underwent attempted ablation of recurrent tachycardia 2014

By courtesy of John Miller, MD
Overdrive Pacing @ distal CS with 200 msec

TCL 230 ms

RA at TCL

RA at PCL

NNE: 7

2 + 5

CS at TCL

CS at PCL

CS-p

Abl-d

Abl-p

TA 1-2

His-d

His-p

V5

V1

1

2

3

4

5
Overdrive Pacing @ Lateral RA with 200 msec

TCL 230 ms

RA at TCL

RA at PCL

NNE: 2

2 + 0

CS at TCL

CS at PCL

By courtesy of John Miller, MD
Overdrive Pacing from RA for LA tachycardia

Keimyung University Dongsan Medical Center
Overdrive Pacing from LA for LA tachycardia

NNE: 5

RA@TCL
LA@PCL
RA@PCL
LA@PCL

Keimyung University Dongsan Medical Center
Novel Approach to Differentiate The Origin of Macroeentrant Atrial Tachycardia

Seongwook Han, MD PhD FHRS, John Garner, MD, Nicholay Teodorovich, MD, Changyu Shen, PhD, John M Miller, MD FHRS
Purpose

We sought to determine whether the number of stimuli needed to capture the chamber paced vs. both atria would help in localizing the chamber of AT origin.
Methods

- We enrolled 42 macroreentrant ATs (right:left = 20:22) of which origin was confirmed by termination during radiofrequency energy application.

- During AT, entrainment pacing was performed from multipolar catheter in the right atrium (RA) and from coronary sinus catheter in the left atrium (LA).
Methods

- Capture of an atrium was defined as advancement of all electrograms in that chamber to the pacing cycle length.

- We assessed the difference between the number of pacing required to capture the paced atrium and non-paced atrium ($\Delta$ capture).
Results

RA macroreentrant tachycardia

RA pacing
LA pacing

Delta to Bi-Atrial Capture

P < 0.001
Results

LA macroreentrant tachycardia

RA capture  LA capture

RA pacing  8.7  13.6
LA pacing  6.8  5.3

Delta to Bi-Atrial Capture

RA pacing  4.9
LA pacing  1.5

P<0.001

Han S, Miller JM et al. ACC 2013 PO1-80
Results

- Pacing from the atrium ipsilateral to the AT origin captured the other atrium as soon as the paced atrium was fully captured.

- Pacing from the atrium contralateral to the AT origin needed significantly more stimuli to capture the non-paced atrium ($P<0.05$).
Results

- Localizing AT to the LA
  The difference of $\Delta$ capture (RA pacing - LA pacing) $\geq 0$

![Bar chart showing sensitivity and specificity](chart.png)

- Sensitivity: 100 (95% CI: 81~100%)
- Specificity: 94 (95% CI: 70~100%)
Conclusion

- The *difference of delay in non-paced chamber* can be used as a rapid and reliable parameter to *localize* the origin of macroreentrant AT, *irrespective of limitations of entrainment mapping*
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Thank You for Your Attention!