Mapping and Ablation in AF: how can we evaluate the lesion formation?

Dhiraj Gupta MD DM FRCP
Consultant Cardiologist
Liverpool Heart and Chest Hospital
MY CONFLICTS OF INTEREST ARE

Research Grants, Hospitality and Speaker Fees from Biosense Webster Inc.
Proctor fees from St Jude Medical Ltd
Disclaimer

• This presentation reflects the techniques, approaches and opinions of the individual presenter(s).

• This Biosense Webster, Inc. sponsored presentation is not intended to be used as a training guide. Before using any medical device, review all relevant package inserts with particular attention to the indications, contraindications, warnings and precautions, and steps for use of the device(s).

• All content of this presentation is owned by their authors and is protected by worldwide copyright laws.

• I am compensated by and am presenting on behalf of Biosense Webster, Inc.
Liverpool
Liverpool Heart and Chest Hospital

- 1400 EP cases annually (550 AF cases)
- Predominantly Carto-based PVI since 2009
- BWI External Evaluation Site for
  - Carto version 3.3 (2012)
  - ST SF catheters (June 2014)
  - Carto version 4.0 (Aug 2014)
  - Ablation Index (Nov 2014)
Parameters to evaluate lesion formation

- Contact Force
- Energy delivery Time
- Power
- Impedance decrease
- Electrogram Changes
- Electrode and Tissue temperature
Limitations of FTI

No allowance for Power

Lesion size with FTI 300 3 times bigger for 35W than 20W*

No allowance for Parabolic nature of lesion creation

application duration contributes little to lesion size beyond 20secs **

* Guerra JM et al, J Cardiovasc Electrophysiol 2013; 24:1157-62
** Wittkampf FH et al, Circulation 1989; 80: 962-68
A formula developed by Nakagawa et al based upon biophysics of lesion formation
Based upon retrospective analysis of lesion depth in canine RV and LV
Greater impact of Power over Contact Force
Greater impact of the Initial Phase of Ablation
Prospective Study to Test the Ability to Create RF Lesions at Predicted Depths of 3, 5, 7 and 9 mm Using a New Formula Incorporating Contact Force, Radiofrequency Power and Application Time (Force-Power-Time Index) in the Beating Canine Heart. Heart Rhythm 2013;10:S481
FPT Integral to ‘Ablation Index’

- FPTI was introduced as ABLATION INDEX in Carto® 3, v4 (external evaluation)
  - Not validated to assess lesion depth in human tissue
- First Phase: AI could be reviewed retrospectively
- Second Phase: AI could be monitored prospectively
  - AI Bars
  - AI color coded tags
  - Force sampled every 50 ms (Carto)
  - Power sampled every 100 ms (Stockert™)
Clinical Evaluation of Ablation Index

<table>
<thead>
<tr>
<th>Evaluation of Force, Time, Stability (CF catheter and FTI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOCCATA</strong></td>
</tr>
<tr>
<td>3D and CF guided PVI</td>
</tr>
<tr>
<td>Unblinding of FTI</td>
</tr>
<tr>
<td>Clinical Outcome vs FTI</td>
</tr>
<tr>
<td>N=32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation of Force, Power, Time, Stability (Ablation Index)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multicentre Analysis</strong></td>
</tr>
<tr>
<td>3D and CF guided PVI</td>
</tr>
<tr>
<td>Unblinding of AI</td>
</tr>
<tr>
<td>Acute Gaps vs AI</td>
</tr>
<tr>
<td>N=155 (Liverpool, Bruges, Aarhus, Bad Kronizen)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Phase 1: Multicentric Study to develop AI

Hiroshi Nakagawa, Oklahoma

- Mattias Duytschaever, Bruges, Belgium
- Dhiraj Gupta, Liverpool, UK
- Amir Jadidi, Freiburg, Germany
- Peter Lukac, Aarhus, Denmark
Ablation Protocols

• Lasso guided PbP-PVI, Adenosine and >20’ waiting

• Thermocool Smatrtouch® and Visitag™ module
  • Catheter Position Stability: 5-8 sec, 2-3 mm
  • Force over Time: 3-5 g, >30-40%
  • Impedance Drop not targeted

• Minimum Target CF 5-10 g

• FTI target of 400 used at Bruges and BK
Ablation Index Predicts Sites of Acute Reconnection after Pulmonary Vein Isolation: A Multi-Center Retrospective Analysis

Moloy Das, Mattias Duyschaefer, Dhiraj Gupta, Peter Lukac, Jeremie Sorrel, Thomas Phlips, Amir S. Jaddidi, Hiroshi Nakagawa
1Liverpool Heart and Chest Hospital, UK; 2St Jan Hospital Bruges, Belgium; 3Aarhus University Hospital, Denmark; 4University Heart Center Freiburg–Bad Krozingen, Germany; 5University of Oklahoma Health Sciences Center Heart Rhythm Institute, OK, USA

Introduction
• Delivery of transmural ablation lesions during pulmonary vein isolation (PVI) for atrial fibrillation (AF) is of critical importance
• In a previous canine study on RF ablation, lesion depth was described accurately by a logarithmic function of contact force (CF), power and application time (Force-Power-Time Index Formula)
• Ablation Index (CARTo® 3 V4) utilises this formula to predict lesion depth at each ablation site
• We hypothesized that the minimum Ablation Index value within a segment of a circumferential PVI ring would predict acute segment reconnection

Methods

Study population
• 159 AF patients undergoing CPVI in 4 centers were retrospectively studied (age 60±10 years, 70% male, 87% paroxysmal AF, LAd 41±5mm).

PVI procedure
• CPVI was performed using operator-selected CF, time and power settings
• VisiTag™ automated lesion tagging was utilised in all cases, using operator –specified settings:
  • Catheter Position Stability:
    • Minimum time: range 3-10secs (median 8secs)
    • Maximum range: range 2-5mm (median 3mm)
    • Force Over Time:
      • Time: range 30-70% (median 30%)
      • Minimum CF: range 3-10g (median 5g)

Assessment for acute PV reconnection
• PVs were assessed for acute reconnection with a circular catheter after a minimum 20-minute waiting period
• Adenosine was administered to unmask dormant acute reconnection
• Sites of acute reconnection were recorded according to a 9-segment model
• For each subject, the ablation maps was reviewed offline to identify the Ablmin for each of the 9 CPVI segments (Figures 1 and 2)

Aims

We aimed to retrospectively analyse the relationship between the minimum Ablation Index value (Ablmin) within a circumferential PVI (CPVI) segment and acute reconnection of that segment (spontaneous or adenosine-mediated) in patients with AF undergoing PVI.

Results

Prevalence of acute PV reconnection
Acute reconnection was identified in:
• 49 of 159 (31%) patients
• 80 of 1413 (6%) CPVI segments

Predictive value of Ablmin
The median Ablmin for acutely reconnected segments was significantly lower than that for non-reconnected segments (median 293 [IQR 255-344] vs. 342 [293-397], P<0.0001, Figure 3).

Regional differences
Median Ablmin values for individual segments by reconnection status are shown in Table 1

Table 1

<table>
<thead>
<tr>
<th>Segment</th>
<th>No reconnection</th>
<th>Acute reconnection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>350</td>
<td>293</td>
</tr>
<tr>
<td>Anterior</td>
<td>362</td>
<td>351</td>
</tr>
<tr>
<td>Ridge</td>
<td>364</td>
<td>291</td>
</tr>
<tr>
<td>Posterior</td>
<td>315</td>
<td>286</td>
</tr>
<tr>
<td>Inferior</td>
<td>328</td>
<td>270</td>
</tr>
</tbody>
</table>

Conclusions

• The Ablmin within a CPVI segment predicts acute reconnection within that segment
• Higher Ablmin values are required for anterior/ridge/roof segments than for posterior/inferior segments to prevent acute reconnection, suggesting thicker LA wall in these regions
Phase 1: Multicentric Study to develop AI

Acute reconnection identified in
- 49 of 159 (31%) patients
- 80 of 1413 (6%) segments

<table>
<thead>
<tr>
<th>Segment</th>
<th>No reconnection</th>
<th>Acute reconnection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>350</td>
<td>293</td>
</tr>
<tr>
<td>Anterior</td>
<td>362</td>
<td>351</td>
</tr>
<tr>
<td>Posterior</td>
<td>315</td>
<td>286</td>
</tr>
<tr>
<td>Inferior</td>
<td>328</td>
<td>270</td>
</tr>
</tbody>
</table>

The 100% PPV $A_{\text{min}}$ thresholds associated with no ARC
- 380 for posterior/inferior segments
- 550 for anterior/ridge segments
Multicentric analysis of Ablation Index

- Unblinding of the Ablation Index in CF/FTI guided ablation revealed a **wide variation** in reached AI values
- The **marked consistency** across the 4 centres allows to prespecify region-specific targets for AI-guided ablation
- This suggested a potential **incremental benefit** of on top of CF/FTI-guided ablation
Phase 2: Late PV reconnection and AI PRESSURE study

- Prospective Trial: 80 patients with PAF
- Randomised to mandatory repeat EP procedure at 2 months, or routine management
  - All Antiarrhythmic drugs stopped at 4 weeks
  - Daily ECG recordings for 12 months

NCT01942408, Funded by BSW grant, IIS-239
## Enduring PV isolation

<table>
<thead>
<tr>
<th></th>
<th>EFFICAS I (n=40/46)</th>
<th>EFFICAS II (n=24/26)</th>
<th>PRESSURE (n=40/40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ablation Tools</td>
<td>Endosense/Ensite</td>
<td>Endosense/Ensite</td>
<td>Smartouch/ Carto</td>
</tr>
<tr>
<td>Technique</td>
<td>Blinded to CF</td>
<td>CF &amp; FTI target</td>
<td>CF and Visitag guided</td>
</tr>
<tr>
<td>Late RC</td>
<td>Patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26/40 (65%)</td>
<td>9/24 (38%)</td>
<td>25/40 (62%)</td>
</tr>
<tr>
<td></td>
<td>Circles</td>
<td>39/80 (49%)</td>
<td>12/48 (24%)</td>
</tr>
<tr>
<td></td>
<td>44/160 (28%)</td>
<td>14/91 (15%)</td>
<td>40/160 (25%)</td>
</tr>
<tr>
<td></td>
<td>Segments</td>
<td>52/318 (16%)</td>
<td>14/192 (7.2%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>53/480 (11%)</td>
</tr>
</tbody>
</table>

EFFICAS II: J Kautzner et al, Europace 2015;17:1229-35
PRESSURE: M Das et al, Circ Arrhythm Electrophysiol 2015 (in press)
Distribution of reconnected segments

Right WACA

- Roof: 0
- Posterior: 16
- Anterior: 4
- Inferior: 7

Left WACA

- Roof: 1
- Posterior: 7
- Anterior: 13
- Inferior: 5
<table>
<thead>
<tr>
<th></th>
<th>Ablation Index value</th>
<th>Force Time Integral (gsecs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-reconnected</td>
<td>Reconnected</td>
</tr>
<tr>
<td>Roof</td>
<td>402 (346-441)</td>
<td>294*</td>
</tr>
<tr>
<td>Anterior</td>
<td>410 (358-452)</td>
<td>342 (290-395)</td>
</tr>
<tr>
<td>Posterior</td>
<td>344 (303-394)</td>
<td>295 (250-330)</td>
</tr>
<tr>
<td>Inferior</td>
<td>349 (296-384)</td>
<td>301 (236-322)</td>
</tr>
</tbody>
</table>

Univariable regression analysis: both minimum AI and minimum FTI predictive of reconnection (P<0.0001)
Multivariable model: Only minimum AI independently predictive (P=0.019) whereas minimum FTI was not (P=0.193)
The 100% PPV $A_{\text{min}}$ thresholds associated with no late RC
- 370 for posterior/inferior segments
- 480 for anterior/ridge/roof segments
Phase 3: Ablation Index guided ablation

Ablation Index
Target Values

550 Anterior

Roof

RSPV

RIPV

Inferior

Posterior

400 Posterior

Right WACA

550 Anterior

Ridge

Roof

LSPV

LIPV

Inferior

Inferior

Left WACA
AI guided Ablation Protocol

- Lasso guided PbP-PVI, Adenosine and >20’ waiting
- Smarttouch Thermocool® and Visitag™ with Ablation Index
  - Catheter Position Stability: 8 sec, 3 mm
  - Force over Time: >3g, >30%
- Target CF 10-40g, Target Power 35-40 W
- Contiguous and continuous lesions
- Ablation Index target of 400 on Post Wall, 550 on Ant Wall
- If incomplete lesion (pink tag), cover if due to dislocation
Phase 3: Ablation Index guided ablation

Contiguity along the circles
Ablation index

FTI >400 gs

Δ-Imp >10Ω

Δ-Imp >8Ω
### Right WACA Circle

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF time, s</td>
<td>966</td>
</tr>
<tr>
<td>Applications, n</td>
<td>39</td>
</tr>
<tr>
<td>Mean duration of applications, s</td>
<td>24</td>
</tr>
<tr>
<td>Isolation after First Pass</td>
<td>Yes</td>
</tr>
<tr>
<td>Reconnection with Adenosine and 20’ wait</td>
<td>No</td>
</tr>
</tbody>
</table>

### Left WACA Circle

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF time, s</td>
<td>1159</td>
</tr>
<tr>
<td>Applications, n</td>
<td>40</td>
</tr>
<tr>
<td>Mean duration of applications, s</td>
<td>29</td>
</tr>
<tr>
<td>Isolation after First Pass</td>
<td>Yes</td>
</tr>
<tr>
<td>Reconnection with Adenosine and 20’ wait</td>
<td>No</td>
</tr>
</tbody>
</table>
### Phase 3: Ablation Index guided ablation

**Comparative data**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CF/FTI (n=50)</th>
<th>Abl’ Ind (n=50)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procedure time, min</strong></td>
<td>194±42</td>
<td>143±17</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Isipilateral encirclement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF time, min</td>
<td>27.7±7.4</td>
<td>17.8±3.8</td>
<td>0.0001</td>
</tr>
<tr>
<td>Isolation after 1st circle, n</td>
<td>55/100 (55%)</td>
<td>98/100 (98%)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Isolation proof to adeno/waiting, n</td>
<td>76/100 (76%)</td>
<td>97/100 (97%)</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Complications</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke/TIA</td>
<td>0/50 (0%)</td>
<td>0/50 (0%)</td>
<td></td>
</tr>
<tr>
<td>Tamponade</td>
<td>1/50 (2%)</td>
<td>0/50 (0%)</td>
<td></td>
</tr>
<tr>
<td><strong>FU at 6 months without blanking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free of Afib, n (%)</td>
<td>40/50 (80%)</td>
<td>48/50 (96%)</td>
<td>0.0001</td>
</tr>
<tr>
<td>N of repeats, n (%)</td>
<td>7 (14%)</td>
<td>2 (4%)</td>
<td></td>
</tr>
</tbody>
</table>

Slide courtesy of Prof M Duytschaever, Bruges
Phase 3: **Pulmonary vein Reconnection following Ablation Index-guided ablation: a Success Evaluation (PRAISE)**

- Prospective cohort study in 50 patients with continuous Persistent AF
  - Liverpool Heart and Chest Hospital, Liverpool, UK (n=40)
  - Centro Cardiologico Monzino, Milan, Italy (n=10)
- Initial PVI procedure will be performed guided by AI targets of 550 for the roof and anterior wall, and 400 for the posterior and inferior walls
- All patients (regardless of AF recurrence) will undergo a repeat EP study at 3 months to identify and re-ablate PV reconnection
- Funded by Biosense Webster (IIS-386)
Summary

- Ablation Index guided PVI is feasible and reproducible
- Shortens RF time and procedure time, and virtually eliminates acute PV reconnection
- Makes procedure times more consistent and predictable
- Effect on long-term lesion durability and clinical efficacy needs to be proven