Surgical treatment of AF

Mark La Meir, Laurent Pison

Centre for Heart Disease, University Hospital, Brussels - Maastricht
Disclosures: consultant Atricure
Know your trade

Mark La Meir, Laurent Pison

Centre for Heart Disease, University Hospital, Brussels - Maastricht
Einthoven W. Le télécardiogramme. Arch Int Physiol 1906; 4: 132–164

AF Mechanisms proposed in 1900-1920

- Multiple circuit reentry
- Mother wave reentry
- Rapidly-discharging ectopic foci

Focal AF pathophysiology

SPONTANEOUS INITIATION OF ATRIAL FIBRILLATION BY ECTOPIC BEATS ORIGINATING IN THE PULMONARY VEINS

MICHEL HAÏSSAGUERRE, M.D., PIERRE JÀIS, M.D., DIPEN C. SHAH, M.D., ATSUSHI TAKAHASHI, M.D., MÉLÈZE HOCHI, M.D., GILLES QUINIOU, M.D., STEPHANE GARRIGUE, M.D., ALAIN LE MOUROUX, M.D., PHILIPPE LE METAYER, M.D., AND JACQUES CLEMENTY, M.D.

Ablation of triggers:
- SR (acute): 84%
- SR (chronic): 62%

Haïssaguerre et al, NEJM 1998;339:659–666
<table>
<thead>
<tr>
<th>Group</th>
<th>Patients, n</th>
<th>Age, y</th>
<th>History, y</th>
<th>Other SHD, %</th>
<th>LA Size, mm</th>
<th>Multiple AF Foci, %</th>
<th>Late Recurrence, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPFW</td>
<td>27</td>
<td>63±14</td>
<td>5.2±4.0</td>
<td>50</td>
<td>39.5±5.9</td>
<td>100</td>
<td>56</td>
</tr>
<tr>
<td>SVC</td>
<td>27</td>
<td>57±12</td>
<td>4.7±4.8</td>
<td>22</td>
<td>36.8±5.1</td>
<td>44</td>
<td>26</td>
</tr>
<tr>
<td>CT</td>
<td>10</td>
<td>63±12</td>
<td>4.1±3.2</td>
<td>0</td>
<td>29.7±5.0</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>LOM</td>
<td>6</td>
<td>66±13</td>
<td>3.1±2.5</td>
<td>50</td>
<td>41.3±1.5</td>
<td>83</td>
<td>50</td>
</tr>
<tr>
<td>CSO</td>
<td>1</td>
<td>67</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IAS</td>
<td>1</td>
<td>44</td>
<td>2</td>
<td>100</td>
<td>...</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

A: Circus movement reentry. The size of the anatomical obstacle, the conduction velocity, and the refractory period are the main determinants.

B: Leading circle concept. As no anatomic obstacle exists, the reentry path adopts the minimal possible path length, which depends on conduction velocity and refractory period. The central region is rendered unexcitable by electrotonic depolarization by the circulating fibrillation wave.

C: Rotor theory reentry. The rotor rotates around an excitable yet unexcited core. Lengths of arrows show conduction velocity.

D: Chaotic activation pattern caused by multiple wavelets.

Pathophysiology of atrial fibrillation

Electrical remodeling

Significant abbreviation of the AP duration and conduction slowing
Pathophysiology of atrial fibrillation

- Atrial dilatation ↔ atrial fibrillation
- Atrial fibrillation:
  - loss of myofibrils
  - accumulation of glycogen
  - changes in mitochondrial shape and size
  - fragmentation of sarcoplasmic reticulum
  - dispersion of nuclear chromatin
  - alterations in expression of atrial intercellular gap junctions

Structural remodeling
Goat Atrial Wall

Endocardial View

Epicardial View

S. Verheule
Three-Dimensional Substrate for AF

Acute AF

Persistent AF

B. Maesen
AF ablation
Concomitant AF procedure

R. Damiano
Role of concomitant AF in cardiac surgery:


✓ 7 studies >50 patients, 9 <50.

✓ 14 includes MV surgery, 8 results for CABG.

✓ Most studies focus on AF concomitant with MV.

✓ 7 RF, 4 cut and sew, 3 cryo, 2 MW.
✓ SR at discharge was significantly higher in the CS+SA 62.7% vs 26.6%.

✓ SR at ≥ 12-months 66.7% vs 26.1%.

✓ 30-day all-cause mortality was not significantly different 5.3% vs 3.8%.

✓ Neurological events shows comparable results 4.9% vs 5.8%.

✓ No difference in pacemaker implantations 5.8% vs 8.3%.
✓ Surgical ablation is a viable treatment for AF during concomitant cardiac surgery without increased mortality or morbidity risks.

✓ Short-, mid- and long-term SR prevalence are significantly improved in patients who undergo surgical ablation.

✓ Subgroup analysis of the different ablation techniques showed no significant difference affecting SR.

✓ From 10 RCTs (735 patients), no significant difference was found in terms of neurological events.
Stand-alone AF ablation

Mark La Meir, Laurent Pison

Centre for Heart Disease, University Hospital, Brussels - Maastricht
GAP-AF (AFNET1) study

233 patients with drug refractory PAF were randomized to a complete PVI procedure (n=117) or an incomplete procedure (n=116).

The primary endpoint of the study:
First recurrence of symptomatic AF with duration of more than 30 seconds on trans-telephonic ECG monitoring, or detection of asymptomatic AF defined as two consecutive recordings of AF during a minimum of 72 hours.

Results at three months FU:
Sinus rhythm in 37.8% of patients who had complete ablation, versus 20.8% with incomplete ablation (P<0.001).

70% of those randomised to complete PVI had gaps versus 89% randomised to incomplete PVI.
Problem endocardial catheter ablation

PVI, the basis of most ablation strategies is not guaranteed with a single procedure, therefore building up a lesion set upon PVI is inconsistent.
“AF begets AF“

“Catheter ablation begets catheter ablation“
Catheter Ablation of Long-Standing Persistent Atrial Fibrillation
5-Year Outcomes of the Hamburg Sequential Ablation Strategy

Roland Richard Tilz, MD, Andreas Rillig, MD, Anna-Maria Thum, Anita Arya, MD, Peter Wohlmuth, Andreas Metzner, MD, Shibu Mathew, MD, Yasuhiro Yoshiga, MD, Erik Wissner, MD, Karl-Heinz Kuck, MD, Feifan Ouyang, MD

Hamburg, Germany

Multiple procedures: SR 45%
Single procedure: SR 20%

Most AF recurrences after PVI associated with PV reconnection
What should we try to give the AF patient?

- Longlasting PV isolation
- Connecting lesions
- Line to the mitral annulus
- Excision/exclusion LAA
- Isolation of the coronary sinus
- Lesions in the right atrium
- Ganglionated plexi?

This can not be achieved with an epicardial ablation
Thoracoscopic surgical ablation versus catheter ablation for AF

Eight comparative studies:

- Three are prospectively randomized, five articles were retrospective observation studies

- 321 VATS ablation patients compared with 378 CA patients,

- Two studies treated PAF patients, two studies treated persistent AF patients, the remainder of the studies had a study population of both paroxysmal and persistent AF.
### Table 1: Study characteristics

<table>
<thead>
<tr>
<th>First author</th>
<th>Study period</th>
<th>Country</th>
<th>Study design</th>
<th>n (SA)</th>
<th>n (CA)</th>
<th>PAF</th>
<th>PersAF</th>
<th>Mean follow-up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al., 2014</td>
<td>2008-12</td>
<td>China</td>
<td>P, RCT</td>
<td>66</td>
<td>72</td>
<td>138</td>
<td>0</td>
<td>6-40</td>
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<tr>
<td>Rong et al. 2014</td>
<td>2007-12</td>
<td>China</td>
<td>R, OS (abstract)</td>
<td>16</td>
<td>32</td>
<td>48</td>
<td>0</td>
<td>30.6 ± 18.9</td>
</tr>
<tr>
<td>De Souza et al. 2014</td>
<td>2012-13</td>
<td>UK</td>
<td>R, OS (abstract)</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>De Maat et al. 2014</td>
<td>2009-11</td>
<td>Netherlands</td>
<td>R, OS</td>
<td>33</td>
<td>66</td>
<td>76</td>
<td>23</td>
<td>12.6 ± 2</td>
</tr>
<tr>
<td>Pokushalov et al. 2013</td>
<td>NR</td>
<td>USA</td>
<td>P, RCT</td>
<td>32</td>
<td>32</td>
<td>38</td>
<td>26</td>
<td>12</td>
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<tr>
<td>Boersma et al. 2012</td>
<td>2007-10</td>
<td>Netherlands</td>
<td>P, RCT</td>
<td>61</td>
<td>63</td>
<td>82</td>
<td>42</td>
<td>12</td>
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<tr>
<td>Wang et al. 2011</td>
<td>2006-09</td>
<td>China</td>
<td>R, OS</td>
<td>83</td>
<td>83</td>
<td>0</td>
<td>166</td>
<td>26.4</td>
</tr>
<tr>
<td>Sauren et al. 2009</td>
<td>2007-08</td>
<td>Netherlands</td>
<td>R, OS</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>6</td>
</tr>
</tbody>
</table>

SA: surgical ablation; CA: catheter ablation; PAF: paroxysmal atrial fibrillation; PersAF: persistent atrial fibrillation; P: prospective; R: retrospective; OS: observational study.

### Table 2: Baseline characteristics of thoracoscopic SA versus CA for AF

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SA</th>
<th>CA</th>
<th>RR or WMD, 95% CI</th>
<th>I² (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53.8</td>
<td>55.2</td>
<td>-0.07 (-1.44, 1.31)</td>
<td>0</td>
<td>0.93</td>
</tr>
<tr>
<td>Males (%)</td>
<td>70.5</td>
<td>74.6</td>
<td>0.95 (0.87, 1.04)</td>
<td>0</td>
<td>0.23</td>
</tr>
<tr>
<td>Persistent AF (%)</td>
<td>43.9</td>
<td>43.6</td>
<td>0.97 (0.46, 2.06)</td>
<td>90</td>
<td>0.93</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>33.5</td>
<td>42.8</td>
<td>0.77 (0.61, 0.99)</td>
<td>23</td>
<td>0.04</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>11.1</td>
<td>11.4</td>
<td>0.92 (0.55, 1.52)</td>
<td>0</td>
<td>0.74</td>
</tr>
<tr>
<td>Prior stroke/TIA (%)</td>
<td>12.6</td>
<td>7.1</td>
<td>1.73 (0.93, 3.22)</td>
<td>0</td>
<td>0.08</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>59.6</td>
<td>59.7</td>
<td>-0.19 (-1.81, 1.43)</td>
<td>44</td>
<td>0.82</td>
</tr>
<tr>
<td>LAD (mm)</td>
<td>46.9</td>
<td>46.2</td>
<td>0.48 (-1.01, 1.97)</td>
<td>31</td>
<td>0.53</td>
</tr>
<tr>
<td>AF history (years)</td>
<td>5.9</td>
<td>5.7</td>
<td>0.29 (-0.23, 0.80)</td>
<td>0</td>
<td>0.27</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.8</td>
<td>28.2</td>
<td>-0.43 (-1.37, 0.52)</td>
<td>0</td>
<td>0.37</td>
</tr>
</tbody>
</table>

SA: surgical ablation; CA: catheter ablation; RR: relative risk; WMD: weighted mean difference; CI: confidence interval; AF: atrial fibrillation; TIA: transient ischaemic attack; LVEF: left ventricular ejection fraction; LAD: left atrial diameter; BMI: body mass index.
Figure 3: Forest plot of freedom from atrial fibrillation (AF) in (A) paroxysmal and (B) persistent AF subgroups for thoracoscopic surgical ablation (SA) versus catheter ablation (CA).

Figure 4: Forest plot of repeat procedures for thoracoscopic surgical ablation (SA) versus catheter ablation (CA) for atrial fibrillation.
### Table 3: Complications of thoracoscopic SA versus CA for atrial fibrillation

<table>
<thead>
<tr>
<th>Complication</th>
<th>SA (%)</th>
<th>CA (%)</th>
<th>RR, 95% CI</th>
<th>I² (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality (%)</td>
<td>0</td>
<td>0.5</td>
<td>0.34 (0.01, 8.29)</td>
<td></td>
<td>0.51</td>
</tr>
<tr>
<td>Stroke (%)</td>
<td>0.8</td>
<td>0.7</td>
<td>1.06 (0.16, 7.15)</td>
<td>0</td>
<td>0.95</td>
</tr>
<tr>
<td>TIA (%)</td>
<td>0.6</td>
<td>1.0</td>
<td>0.88 (0.14, 5.69)</td>
<td>4</td>
<td>0.89</td>
</tr>
<tr>
<td>Pneumonia (%)</td>
<td>4.4</td>
<td>1.3</td>
<td>1.98 (0.32, 12.19)</td>
<td>18</td>
<td>0.46</td>
</tr>
<tr>
<td>Pleural effusion (%)</td>
<td>6.2</td>
<td>0</td>
<td>6.95 (1.28, 37.72)</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td>Pneumothorax (%)</td>
<td>6.2</td>
<td>0</td>
<td>9.77 (1.27, 75.32)</td>
<td>0</td>
<td>0.03</td>
</tr>
<tr>
<td>Pericardial effusion/tamponade (%)</td>
<td>3.4</td>
<td>1.7</td>
<td>1.98 (0.50, 7.75)</td>
<td>0</td>
<td>0.33</td>
</tr>
<tr>
<td>Groin haematoma (%)</td>
<td>0</td>
<td>2.8</td>
<td>0.29 (0.05, 1.71)</td>
<td>0</td>
<td>0.14</td>
</tr>
<tr>
<td>Pacemaker implantations (%)</td>
<td>1.4</td>
<td>1.1</td>
<td>1.08 (0.07, 15.69)</td>
<td>52</td>
<td>0.95</td>
</tr>
</tbody>
</table>

SA: surgical ablation; CA: catheter ablation; RR: relative risk; TIA: transient ischaemic attack.

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Figure 5: Forest plot of major complications for thoracoscopic surgical ablation (SA) versus catheter ablation (CA) for atrial fibrillation.
Hybrid Procedure

Team Work
Cardiac ganglionic plexi - Fat Pads

Step by step: right superior GP ablation
Testing the box
Incomplete roofline after epicardial ablation
Redo procedures
Risk Factors for Stroke in AF and AF progression show a large overlap

**CHADS 2 score**

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>CHADS2 score</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Chron heart failure</td>
<td>1</td>
</tr>
<tr>
<td>- Hypertension</td>
<td>1</td>
</tr>
<tr>
<td>- Age &gt; 75</td>
<td>1</td>
</tr>
<tr>
<td>- Diabetes</td>
<td>1</td>
</tr>
<tr>
<td>- Stroke</td>
<td>2</td>
</tr>
</tbody>
</table>

**HATCH score and AF progression**

- H – Hypertension
- A – Age > 75 yrs
- T – Tia or stroke (x2)
- C – COPD
- H – HF history (x2)

Gage BF, et al. JAMA 2001
De Vos CB, et al. JACC 2010
Benefits

- AF?
- Stop Emboli?
- Stop OAC?
Happiness= the longest english word

SMILES

Surgeons Minimal Invasive Love Electrophysiology Studies