Cardiac imaging for atrial fibrillation: Atrial characteristics in atrial fibrillation

Dominic Leung
Liverpool Hospital, Sydney
University of New South Wales
Australia
Atrial characteristics in atrial fibrillation – Why?

- Substrates for AF
- Overall prognostic evaluation
- Thromboembolic risks
- Guide management
  - Choice of therapies
  - Prediction of success with radiofrequency ablation
- Recovery after successful treatment
What atrial characteristics?

- Atrial volume
  - Atrial phasic volumes
- Atrial function
- Left atrium as a thrombogenic milieu
- Atrial fibrosis
- Atrial morphology
Prognostic values of left atrial (LA) volume

- Maximum LA volume of prognostic values
- In older patients
- Specific cardiovascular conditions
  - Coronary artery disease
  - Cardiomyopathy
- Restricted endpoints
- Relatively short duration of follow up
Prognostic values of LA volume

- 483 consecutive patients, in sinus rhythm
- Mean age 47.3 years
- Median maximum LA volume index 24 mL/m²
- Median follow up 6.8 years
- Combined endpoint: cardiac death, stroke, new AF, heart failure, acute myocardial infarction
- Event rate 18.3%

Leung DY et al. Am J Cardiol 2010;105:1635
Event free survival according to median LA volume

Leung DY et al. Am J Cardiol 2010;105:1635
Cox proportional hazard model: Multivariate predictors: Maximal LA volume index of incremental value

<table>
<thead>
<tr>
<th>Predictor</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male</td>
<td>0.025</td>
</tr>
<tr>
<td>History of stroke</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.006</td>
</tr>
<tr>
<td>eGFR &lt; 30</td>
<td>0.004</td>
</tr>
<tr>
<td>Enlarged left atrium &gt; 24 mL/m²</td>
<td>0.018</td>
</tr>
</tbody>
</table>

Leung DY et al. Am J Cardiol 2010;105:1635
Left atrial volumes

- Maximum LA volume
  - End ventricular systole
- Minimum LA volume
  - End ventricular diastole
- LA emptying volume
  - Maximum – minimum volume
- LA ejection fraction
  - Emptying volume/Maximum volume
Image courtesy of Dr Victoria Delgado and Jeroen Bax
Left atrial phasic volumes

- Passive emptying volume
  - Maximum volume – pre P volume

- Active emptying volume
  - Pre P volume – minimal volume

- Conduit volume
  - LV stroke volume – total emptying volume

Leung DY et al. Am Heart J 2008;156:1056
LA phasic volumes after radiofrequency catheter ablation for AF

- N = 57
- LA volumes by 3D echo
- Success 43 (75%)
- Recurrence 14 (25%)
- Decrease in maximum and minimal volumes only in success group at 3 months

Marsan MA et al. Am J Cardiol 2008;102:847
Left atrial reverse remodelling 3 months after successful catheter RF ablation

Tops LF et al. Am J Cardiol 2006;97:1220
Left atrial function

- Mitral A wave
- Tissue Doppler a’ velocities
  - Global atrial function
Differential impact on LA function: 6 months post successful linear RF ablation vs cardioversion

Thomas L et al. Am J Cardiol 2004;93:165
Segmental left atrial function

Leung DY et al. Am Heart J 2008;156:1056
Impact of linear RF ablation on regional left atrial function

Tissue Doppler velocities not site specific
But tissue deformity in atrium opposite direction to that of the ventricle
Atrial strain

Peak strain (+)

Reservoir

Contractile

Conduit

02/06/2008 15:24:20
S/E: 0/521 ms
SL: 12.0 mm
Rel.: 8%
CC: 1
Octave:
Freq.: 1.9 MHz/4.0 MHz
FPS: 102.7/102.7
Freq.: 2.4 MHz
Atrial strain rate
Atrial function post cardioversion from atrial fibrillation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control (n=37)</th>
<th>Cardioverted AF (n=37)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum LA volume (mL)</td>
<td>37.7 ± 3.1</td>
<td>76.2 ± 3.2</td>
<td>0.001</td>
</tr>
<tr>
<td>LA EF (%)</td>
<td>50.1 ± 2</td>
<td>31.8 ± 2</td>
<td>0.001</td>
</tr>
<tr>
<td>A velocity (m/s)</td>
<td>0.76 ± 0.03</td>
<td>0.34 ± 0.03</td>
<td>0.001</td>
</tr>
<tr>
<td>A’ velocity (cm/s)</td>
<td>9.4 ± 0.3</td>
<td>3.8 ± 0.3</td>
<td>0.001</td>
</tr>
<tr>
<td>Septal A sr (/s)</td>
<td>-1.5 ± 0.1</td>
<td>-0.64 ± 0.1</td>
<td>0.001</td>
</tr>
<tr>
<td>T – Asr (s)</td>
<td>0.47 ± 0.03</td>
<td>0.56 ± 0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Peak + atrial strain (%)</td>
<td>21.1 ± 1.6</td>
<td>10.4 ± 1.6</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Thomas L et al. Heart 2007;93:89
Temporal recovery of atrial function post cardioversion from atrial fibrillation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>After cardioversion</th>
<th>1 month</th>
<th>6 months</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septal A sr (/s)</td>
<td>-0.53</td>
<td>-1.01</td>
<td>-1.1</td>
<td>0.001</td>
</tr>
<tr>
<td>A velocity (m/s)</td>
<td>0.34</td>
<td>0.71</td>
<td>0.77</td>
<td>0.001</td>
</tr>
<tr>
<td>LA EF (%)</td>
<td>30.2</td>
<td>36</td>
<td>42</td>
<td>0.001</td>
</tr>
<tr>
<td>A’ velocity (cm/s)</td>
<td>3.9</td>
<td>7.3</td>
<td>8.5</td>
<td>0.001</td>
</tr>
<tr>
<td>T – Asr (s)</td>
<td>0.55</td>
<td>0.58</td>
<td>0.59</td>
<td>NS</td>
</tr>
</tbody>
</table>

Thomas L et al. Heart 2007;93:89
LA strain at baseline predicts reverse remodelling after ablation

P = 0.001

Remodeler
↓ $\text{LA}_{\text{max}} \geq 15$

Non-remodeler
↓ $\text{LA}_{\text{max}} < 15$

Tops LF et al, JACC in press

Courtesy of Drs Delgado and Bax
LA strain rate at baseline predicts reverse remodelling after ablation

Remodeler
\[\Delta \text{LA}_{\text{max}} \geq 15\%\]

Non-remodeler
\[\Delta \text{LA}_{\text{max}} < 15\%\]

Tops LF et al, JACC in press

Courtesy of Drs Delgado and Bax
Total atrial conduction time predicts new AF after myocardial infarct
N = 613

38 (6.2%) had new AF on follow up

Antoni ML et al. Am J Cardiol 2010;106:198
Left atrium as thrombogenic milieu

- Left atrial size
- Left atrial thrombus
- Left atrial spontaneous echo contrast (smoke)
  - Atrial fibrillation
  - History of thromboembolism
  - Mitral stenosis
  - Atrial thrombus
Left atrial spontaneous echo contrast: Prognostic implications

Figure 1. Cumulative freedom from stroke or other embolic events in patients with (SEC present) and without (SEC absent) baseline left atrial spontaneous echo contrast (SEC).
TEE substudy of SPAF III

- 382 patients with non valvular atrial fibrillation
- Independent predictors of ischaemic stroke on follow up
  - Left atrial thrombus (3x)
  - Dense spontaneous echo contrast (3x)
  - Complex aortic atheroma (4x)

Left atrial emptying velocities

- 271 patients with AF
- Independent predictors of stroke on follow up
  - Dense spontaneous echo contrast
  - Low left atrial appendage emptying velocities of < 20 cm/sec

Left atrial fibrosis

- Delayed enhancement MRI
- 24 patients paroxysmal AF
- 31 patients persistent AF
- Left atrial strain and strain rate by velocity vector imaging

Kuppahally SS et al. Cir Cardiovasc Imaging 2010;3:231
<table>
<thead>
<tr>
<th>Patient 1</th>
<th>Patient 2</th>
<th>Left Atrial Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="" /></td>
<td><img src="image2.png" alt="" /></td>
<td><img src="image3.png" alt="graph" /></td>
</tr>
</tbody>
</table>

**Posterior View - Mild Fibrosis**

**Posterior View - Extensive Fibrosis**

Kuppahally SS et al. *Cir Cardiovasc Imaging* 2010;3:231
Echo predictors of degree of LA fibrosis

- LA lateral wall positive strain and strain rate (inverse correlation)
- Maximum LA volume (direct correlation)
- Persistent AF more fibrosis than paroxysmal AF (22 ± 17% vs 14 ± 9%, p=0.04)

Kuppahally SS et al. Cir Cardiovasc Imaging 2010;3:231
Degree of left atrial fibrosis

- Not correlated with
  - Patient age
  - Clinical risk factors eg hypertension
  - LV filling pressures
  - Mitral regurgitation

Kuppahally SS et al. Cir Cardiovasc Imaging 2010;3:231
Left atrial tissue characterisation with calibrated integrated backscatter

- Calibrated integrated backscatter
- Ultrasonic reflectivity of tissue
- Measure of fibrosis
LA volume and fibrosis

- 170 patients undergoing RF ablation for AF

Courtesy of Dr Victoria Delgado and Dr Jeroen Bax
LV volume / fibrosis and recurrence

Rhythm at follow-up (%)

- Small LA + Low Fibrosis (n=52): 6% Non-recurrence, 94% Recurrence
- Small LA + High Fibrosis (n=32): 38% Non-recurrence, 62% Recurrence
- Large LA + Low Fibrosis (n=33): 18% Non-recurrence, 82% Recurrence
- Large LA + High Fibrosis (n=53): 28% Non-recurrence, 72% Recurrence

Courtesy of Dr Victoria Delgado and Dr Jeroen Bax
Summary – atrial characteristics

- Maximum left atrial volume
  - Independent and incremental prognostic values
- Atrial function
  - Predicts remodelling after restoration of sinus rhythm
  - Predicts maintenance of sinus rhythm
  - Differential impact of cardioversion and RF ablation
  - Predicts new AF after myocardial infarct
Summary – atrial characteristics

- Thromboembolic risks
- Atrial fibrosis
  - Related to LA function
  - Success of RF ablation
If I have not made myself clear…

- 4D, true colour, left atrial model
- Surgeon’s view of the left atrium with the roof removed
- Looking down onto the mitral valve from above
Atrial characteristics in sinus rhythm
Atrial characteristics in atrial fibrillation
I hope I have made myself clear

- Thank you very much for your attention