Characterisation of the Structural and Electrical Impact of an Atrial Septal Defect:
CMR Evaluation of the Arrhythmia Substrate

Louisa O’Neill
Clinical Research Fellow

Division of Imaging Sciences and Biomedical Engineering
St Thomas’ Hospital & King’s College London

louisa.oneill@kcl.ac.uk
Background

- Atrial Septal Defects very common – prevalence 2/1000 live births
- Associated with atrial arrhythmia (AA)
  - 10% in young, > 20% over 40 years
- Ongoing risk of recurrent and new AAs after closure
Background

- Very little data on atrial arrhythmia substrate in ASDs
  - Electrical remodelling
  - Structural remodelling - atrial fibrosis
  - drivers of AF

- Some histological evidence of atrial fibrosis

- No atrial CMR evaluation studies to date
Atrial Late Gadolinium Enhancement

• Atrial LGE-CMR is the only non invasive tool for assessment of atrial fibrosis

• Linked to disease severity and outcome post ablation in non-ACHD AF populations

• May be used to inform patient selection for ablation

• Has not yet been employed in ASD patients

• Very little data available on RA fibrosis
Hypotheses

• Right atrial fibrosis is present in patients with ASDs

• The right atrium plays a role in arrhythmogenesis in this cohort
Aims

• To evaluate the presence of bi-atrial fibrosis in patients with ASDs and to identify CMR parameters associated with the presence of atrial arrhythmias.
Methods

25 Uncorrected ASD patients

Pre procedure CMR
- Atrial LGE
- RV/LV SAX imaging
- Qp:Qs (ASD)

Post processing
- RA and LA fibrosis maps
- RA and LA % fibrosis

Clinical Features Recorded

20 Non ACHD patients (PAF for ablation)
Methods – Atrial LGE sequence

- Anatomical scan for LA and PV segmentation
  - MR angiogram

- 3D LGE
  - 20 minutes after gadolinium
  - Respiratory-navigated, ECG-triggered
  - Inversion time from Look Locker
  - 1.3 x 1.3 x 4 mm; ~50 slices
  - Reconstructed to 0.94 x 0.94 x 2 mm
  - Acquisition window <150 ms

Siemens 1.5T scanner
Methods – post processing
Methods – post processing
Fibrosis Quantification

• Image Intensity Ratio

• Two thresholds for fibrosis used
  IIR 0.97 \(^1\)
  IIR 1.2 \(^2\)

• Fibrosis score for each chamber - % of chamber area with
  signal intensity > threshold value

1. Khurram et al ‘Magnetic resonance image intensity ratio, a normalized measure to enable interpatient comparability of left atrial fibrosis’ Heart Rhythm 2014
2. Benito et al ‘Left atrial fibrosis quantification by late gadolinium-enhanced magnetic resonance: A new method to standardize the thresholds for reproducibility’ Europace 2017
Results

- 25 study patients
  Uncorrected ASDs
  7 Atrial arrhythmias – 3 flutter, 4 Afib
  Defect size – 2.01 ±0.8cm,
  Qp:Qs – 2.2 ±0.8

- 20 control patients
  PAF for ablation
  Structurally normal hearts
  Mean duration of AF – 1.3 years

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Case</th>
<th>Control</th>
<th>P value</th>
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<tbody>
<tr>
<td>Age</td>
<td>52.48±13.83</td>
<td>62±11.4</td>
<td>0.020</td>
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<tr>
<td>Male sex</td>
<td>10 (40%)</td>
<td>11 (55%)</td>
<td>0.401</td>
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<tr>
<td>RA area (cm²)</td>
<td>35.8±9.33</td>
<td>21.71±5.36</td>
<td>&lt;0.001</td>
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<tr>
<td>LA area (cm²)</td>
<td>28.4±7.4</td>
<td>26.5±5.8</td>
<td>0.363</td>
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<tr>
<td>RVEDV/m²</td>
<td>145.1±44.89</td>
<td>72.5±17.9</td>
<td>&lt;0.001</td>
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<td>LVEDV/m²</td>
<td>68.1±20.15</td>
<td>68.3±16.1</td>
<td>0.678</td>
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<td>RVEF (%)</td>
<td>58.6±9.8</td>
<td>59.9±7.1</td>
<td>0.649</td>
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<tr>
<td>LVEF (%)</td>
<td>63.6±9.7</td>
<td>61.5±5.7</td>
<td>0.435</td>
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</tbody>
</table>
Results – Fibrosis Burden between Groups

RA fibrosis – IIR 0.97
- 65.9±11.8% in ASD
- 48.7±15.1% in controls   P<0.001

RA fibrosis – IIR 1.2
- 23.9±18.2% in ASD
- 7.6±7.6% in controls   P<0.001

LA fibrosis – IIR 0.97
- 50.8±11.2% in ASD
- 43.1±9.5% in controls   P=0.013

LA fibrosis – IIR 1.2
- 17.4±10.8% in ASD
- 7.3±4.1% in controls   P<0.001
ASD

Control
Results – Fibrosis Scores within Groups

**ASD Group**
- IIR 0.97 - RA 65.9%  
  - LA 50.8%, $P<0.001$
- IIR 1.2 - RA 23.9%  
  - LA 17.4%, $P=0.063$

**Control Group**
- IIR 0.97 - RA 48.7%  
  - LA 43.1%, $P=0.05$
- IIR 1.2 - RA 7.6%  
  - LA 7.3%, $P=0.813$
Results – Associations with AAs - ASD

- Age and RA area significantly associated with presence of arrhythmia
- No significant differences in fibrosis burden between ASD patients with or without AAs
Conclusions

• RA fibrosis is present in ASD patients to a greater extent than in normal heart PAF controls

• RA fibrosis burden is greater than LA fibrosis burden in ASD patients

• RA size and age are associated with the presence of atrial arrhythmias in ASD patients

• Further work is needed to determine the relationship between right fibrosis and invasive parameters of electrical remodeling and future risk of development of atrial arrhythmias
Thank you
LA Late Gadolinium Enhancement

Mild

Moderate

Severe
Reproducibility data

- **Inter-scan, post ablation**
  - $R^2 = 0.8097$

- **Intra-scan, inter-observer**
  - $R^2 = 0.7686$

- **Intra-scan, intra-observer**
  - $R^2 = 0.8657$