National Institute for Health Research Biomedical Research Centre at Barts

25,000 imaged participants and rising – the power of UK Biobank heart data

UK Biobank Scientific Conference 2018 in London

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Disclosures

• Consultancy, Circle Cardiovascular Imaging Inc., Calgary, Canada

This research has been conducted using the UK Biobank Resource. Access application 2964 (PI Petersen).
Creation of CMR reference standard
LV and RV contours

End-Diastole  End-Systole

BHF project grant (PG/14/89/31194)
1. Left ventricle [7-15 mins]
2. Right ventricle [5-10 mins]
3. Left atrium [3-4 mins]
4. Right atrium [2-3 mins]
5. Strain: [15-30 mins]
6. Aortic structure and function [20 mins]
7. Aortic valve flow: [2 mins]
8. Non-contrast T1 mapping: [15 mins]

Total of up to 109 mins + Loading of study (3 mins) [multiple times: 10 mins] + ~15-20% buffer for downtimes and technical issues

Total ~140 mins per study

Manual expert analysis takes 7 times as long as acquiring the images

Time taken from start to finish ~ 7 months with 8 expert analysts for 5000 CMR scans

What about the rest of 95,000 CMR studies!

Human Resource and time requirement for manual analysis
Quantification of LV function and mass by cardiovascular magnetic resonance: multi-center variability and consensus contours

Avan Suinesiaputra, David Raymond Kwong, Sven P and Eike Nagel
Reference ranges for cardiac structure and function using cardiovascular magnetic resonance (CMR) in Caucasians from the UK Biobank population cohort

Steffen E. Petersen¹, Nay Aung¹, Mihir M. Sanghvi¹, Filip Zemrak¹, Kenneth Fung¹, Jose Miguel Paiva¹, Jane M. Francis², Mohammed Y. Khanji¹, Elena Lukaschuk², Aaron M. Lee¹, Valentina Carapella², Young Jin Kim²,³, Paul Leeson², Stefan K. Piechnik² and Stefan Neubauer²
# CMR Reference Ranges for Ages 45-74: Data from the UK Biobank

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th></th>
<th>Female</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left ventricle</strong></td>
<td>Abnormal low</td>
<td>Normal zone</td>
<td>Abnormal high</td>
<td>Abnormal low</td>
</tr>
<tr>
<td>LVEDV (ml)</td>
<td>&lt;93</td>
<td>109 - 218</td>
<td>&gt;232</td>
<td>&lt;80</td>
</tr>
<tr>
<td>LVESV (ml)</td>
<td>&lt;34</td>
<td>39 - 97</td>
<td>&gt;103</td>
<td>31 - 68</td>
</tr>
<tr>
<td>LV mass (g)</td>
<td>&lt;49</td>
<td>59 - 132</td>
<td>&gt;140</td>
<td>49 - 100</td>
</tr>
<tr>
<td>LSV (ml)</td>
<td>&lt;56</td>
<td>64 - 141</td>
<td>&gt;148</td>
<td>46 - 93</td>
</tr>
<tr>
<td>indexed LVEDV (ml/m²)</td>
<td>&lt;52</td>
<td>60 - 110</td>
<td>&gt;117</td>
<td>54 - 94</td>
</tr>
<tr>
<td>indexed LVESV (ml/m²)</td>
<td>&lt;19</td>
<td>21 - 49</td>
<td>&gt;52</td>
<td>19 - 40</td>
</tr>
<tr>
<td>indexed LSV (ml/m²)</td>
<td>&lt;28</td>
<td>32 - 67</td>
<td>&gt;70</td>
<td>29 - 55</td>
</tr>
<tr>
<td>indexed LV mass (g/m²)</td>
<td>&lt;33</td>
<td>35 - 70</td>
<td>&gt;72</td>
<td>51 - 70</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>&lt;47</td>
<td>48 - 69</td>
<td>&gt;70</td>
<td>39 - 71</td>
</tr>
<tr>
<td>LV mass to volume ratio (g/ml)</td>
<td>&lt;0.40</td>
<td>0.42 - 0.84</td>
<td>&gt;0.87</td>
<td>0.39 - 0.71</td>
</tr>
<tr>
<td><strong>Right ventricle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RVEDV (ml)</td>
<td>&lt;99</td>
<td>124 - 248</td>
<td>&gt;260</td>
<td>85 - 168</td>
</tr>
<tr>
<td>RVESV (ml)</td>
<td>&lt;34</td>
<td>47 - 123</td>
<td>&gt;135</td>
<td>27 - 77</td>
</tr>
<tr>
<td>RVSV (ml)</td>
<td>&lt;54</td>
<td>62 - 131</td>
<td>&gt;140</td>
<td>48 - 99</td>
</tr>
<tr>
<td>indexed RVEDV (ml/m²)</td>
<td>&lt;55</td>
<td>68 - 125</td>
<td>&gt;128</td>
<td>53 - 99</td>
</tr>
<tr>
<td>indexed RVESV (ml/m²)</td>
<td>&lt;19</td>
<td>25 - 63</td>
<td>&gt;67</td>
<td>17 - 46</td>
</tr>
<tr>
<td>indexed RVSV (ml/m²)</td>
<td>&lt;30</td>
<td>34 - 67</td>
<td>&gt;69</td>
<td>30 - 59</td>
</tr>
<tr>
<td>RVEF (%)</td>
<td>&lt;40</td>
<td>45 - 65</td>
<td>&gt;68</td>
<td>47 - 68</td>
</tr>
</tbody>
</table>

| **Left atrium**    | Abnormal low          | Normal zone    | Abnormal high           | Abnormal low   |
| Max. LA vol (2Ch) (ml) | <22               | 30 - 104       | >112                    | <22            |
| Max. LA vol (4Ch) (ml) | <23                | 36 - 124       | >125                    | <23            |
| Max. LA vol (Biplane) (ml) | <26             | 37 - 108       | >112                    | <26            |
| LA SV (Biplane) (ml) | <16                  | 23 - 62        | >66                     | <16            |
| indexed Max. LA vol (2Ch) (ml/m²) | <12         | 16 - 53        | >56                     | <12            |
| indexed Max. LA vol (4Ch) (ml/m²) | <14          | 19 - 62        | >63                     | <14            |
| indexed Max. LA vol (Biplane) (ml/m²) | <15       | 19 - 55        | >56                     | <15            |
| indexed LA SV (Biplane) (ml/m²) | <9           | 12 - 32        | >33                     | <9             |
| LA EF (Biplane) (%) | <44                   | 47 - 73        | >75                     | <44            |
| **Right atrium**   |                       |                |                         |                |
| Max. RA vol (4Ch) (ml) | <36                | 43 - 143       | >150                    | <36            |
| RA SV (4Ch) (ml)   | <9                    | 10 - 66        | >66                     | <9             |
| indexed Max. RA vol (4Ch) (ml/m²) | <19          | 22 - 74        | >79                     | <19            |
| indexed RA SV (4Ch) (ml/m²) | <5            | 5 - 33         | >35                     | <5             |
| RA EF (4Ch) (%)    | <21                   | 23 - 58        | >60                     | <21            |

Data described in this table can be found in the paper entitled "Reference ranges for cardiac structure and function using cardiovascular magnetic resonance (CMR) in Caucasians from the UK Biobank population cohort” by Petersen et al. in the Journal of Cardiovascular Magnetic Resonance, 2017. DOI 10.1186/s12968-017-0327-9
Borderline zone data can be found in the main manuscript.
UK Biobank hits the news (a little) with CMR data
Importance of body mass index and blood pressure on heart health

https://doi.org/10.1371/journal.pone.0185114
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0185114
UK Biobank hits the news with CMR data

Prospective association between handgrip strength and cardiac structure and function in UK adults

Overview of attention for article published in PLoS ONE, March 2018

You are seeing a free-to-access but limited selection of the activity Altmetric has collected about this research output. Click here to find out more.

Title: Prospective association between handgrip strength and cardiac structure and function in UK adults
Published in: PLoS ONE, March 2018
DOI: 10.1371/journal.pone.0193124
PubMed ID: 29538386
Authors: Sebastian L. Boyer, Minvi M. Sanghvi, Naiy Kung, Alice Hasling, Jackie A. Cooper, José Miguel Peiro...
Abstract: Handgrip strength, a measure of muscular fitness, is associated with cardiovascular (CV) events...

Twitter Demographics: The data shown below were collected from the profiles of 35 tweeters who shared this research output. Click here to find out more about how the information was compiled.
Fig 2. Association between baseline handgrip strength and cardiac structure and function by age, adjusted for all covariates.


http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0193124
UK Biobank hits the news with CMR data

The impact of menopausal hormone therapy (MHT) on cardiac structure and function: Insights from the UK Biobank imaging enhancement study

Overview of attention for article published in PLoS ONE, March 2018

SUMMARY

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<td>Authors</td>
<td>Mihir M. Sanghvi, Noy Aung, Jackie A. Cooper, José Miguel Penas, Aaron M. Lee, Filip Zemrak... [show]</td>
</tr>
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<td>Abstract</td>
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TWITTER DEMOGRAPHICS

The data shown below were collected from the profiles of 52 tweeters who shared this research output. Click here to find out more about how the information was compiled.

Metrics as of June 21, 2018
Automation -> New phenotypes

Ventricular filling pattern and diastology

Minimum volume (single-click): 52.8 ml
Maximum volume (double-click): 139.7 ml
Stroke volume: 86.9 ml
Position:
Time to peak filling rate: 109.8 ml
Diastolic volume recovery: 150.6 ms

Ewave (single-click): 55.4 ml/s
Awave (double-click): 440.4 ml/s
SV-adjusted peak-filling rate: 0.6 per
Position:
Deceleration time: 164.6 ms
CMR cine derived “Radiomics”

SHAPE

- Sphericity
- Compactness
- Elongation
- Axis
- Curvature

SIZE

- Volume
- Max diameter
- Surface area
- Volume to surface ratio

EDGE

- Smoothness
- Sharpness
- Irregularity

INTENSITY

- Average
- Variance
- Skewness
- Kurtosis
- Entropy

TEXTURE

- Homogeneity
- Contrast
- Complexity
- Uniformity
- Fractals

Collaboration with K Lekadir, UPF, Barcelona
Conclusions

- The UK Biobank provides unprecedented opportunities to investigate the determinants of health and disease
- UK Biobank enables collaborations to drive science
- Standardisation of CMR analysis
- Clinical impact: Health – risk factors/protective factors – (severity of) disease
- Large-scale cardiac imaging sub-study presents challenges in analysis (expertise, time/cost) -> AI can assist in clearing these obstacles through automation
- UK Biobank will get more powerful over time
  - Increase in sample size for imaging study
  - Outcome data
  - Genetics/blood biomarkers
  - Multi-organ imaging
Thank you

- UK Biobank participants
- Funders (MRC, Wellcome Trust, EPSRC, BHF, NIHR BRC at Barts, Barts Charity)
- UK Biobank team (PI Rory Collins)
- UK Biobank Imaging Enhancement Group (Chair P Matthews)
- UK Biobank CMR co-lead S Neubauer
- Oxford core lab (S Piechnik)
- QMUL/Barts team
- UK Biobank CMR consortium (UKB Access #2964)