Coronary Computed Tomography Angiography and the Future Risk of Myocardial Infarction

5-Year Follow-up of the SCOT-HEART Trial on behalf of the SCOT-HEART Investigators
European Society of Cardiology Guideline
Investigation of Stable Chest Pain

Patients with suspected SCAD and intermediate PTP of 15% - 85%

Consider:
- Patient criteria/s suitability for given test
- Availability
- Local expertise

Stress testing for ischaemia → PTP 15-65% and LVEF ≥50%

Exercise ECG if feasible - stress imaging testing preferred (echo<sup>3</sup>, CMR<sup>2</sup>, SPECT<sup>3</sup>, PET<sup>3</sup>) if local expertise and availability permit

Stress imaging<sup>2</sup> (echo<sup>3</sup>, CMR<sup>2</sup>, SPECT<sup>3</sup>, PET<sup>3</sup>): ECG exercise stress testing possible if resources for stress imaging not available

Coronary CTA<sup>4</sup> in patients at low intermediate PTP (15% - 50%)
- If suitable candidate<sup>4</sup>
- If adequate technology and local expertise available

2nd (imaging) stress test (if not done before)<sup>4</sup>

Coronary CTA in suitable patient<sup>4</sup> (if not done before)<sup>4</sup>

ICA (with FFR when necessary)

Determine patient characteristics and preferences<sup>4</sup>

Unclear

Ischaemia

No ischaemia

No stenosis

Stenosis

Unclear

Consider functional CAD
Investigate other causes

Diagnosis SCAD established further risk stratification (see Fig. 3)

Ischaemia testing using stress imaging if not done before<sup>4</sup>

Montalescot et al. Eur Heart J. 2013;34:2949-3003
Scottish COmputed Tomography of the HEART (SCOT-HEART) Trial

To assess the clinical impact of the addition of CTCA in patients presenting with suspected angina due to coronary heart disease in the Cardiology clinic

- Diagnosis (Primary Endpoint)  Changed Diagnosis in 1 in 4
- Investigations  Changed Investigations in 1 in 6
- Treatments  Changed Treatments in 1 in 4
- Outcomes  
  Pre-specified 5-year outcome: CHD death or non-fatal myocardial infarction

Short-term Effects of CTCA

*Invasive Coronary Angiography and Coronary Revascularisation*

Coronary Revascularisation

HR 1.20 (95% CI, 0.99-1.45), P=0.0611

At 90 days:

- Invasive cardiac catheterisation: 8.1 versus 12.2% (P<0.001)
- Coronary Revascularisation: 3.2 versus 6.2% (P<0.001)

_Lancet_ 2015;385:2383-2391

Short-term Effects of CTCA

Death and Myocardial Infarction at 20-22 Months

CHD death or non-fatal myocardial infarction
HR 0.62 (95% CI, 0.38-1.01), P=0.053

Death or non-fatal myocardial infarction
HR 0.66 (95% CI, 0.44-1.00), P=0.049

ESC Congress
Munich 2018

Lancet 2015;385:2383-2391

Scottish COmputed Tomography of the HEART (SCOT-HEART) Trial

The 5-Year Data

Pre-specified 5-year assessment of Coronary CT Angiography on:

• Coronary heart disease death or non-fatal myocardial infarction
• Invasive coronary angiography and coronary revascularisation
• Prescription of preventative therapies
The SCOT-HEART Trial

Study Protocol

Primary Care Physician Referral

Clinic Consultation
*History, Examination, 12-lead ECG*

Exercise ECG if appropriate

Diagnosis, Investigations and Treatment Plan

Approached for Study Inclusion
*Angina Questionnaire*

Randomised 1:1 to CTCA + Standard Care or Standard Care alone

Computed Tomography Coronary Angiogram

Cardiovascular Risk Assessment: ASSIGN Score

Result to Attending Clinician
*Treatment Recommendations*

6-Week Attending Clinician Review
*Diagnosis, Investigations and Treatment Plan*

6-Week Patient Review
*Angina Questionnaire*

Clinical Outcome
*NHS Health Records*
Randomisation 1:1 to Standard Care Alone or CTCA + Standard Care

- Known CHD?
  - Yes
    - Ensure on appropriate secondary prevention
  - No
    - Standard care

- CT Scan Arm
  - Obstructive CHD
    - 10 year CVD Risk ≥20%?
      - No
        - Letter to patient, primary care physician and consultant
          - Low risk of CVD
      - Yes
        - Letter to primary care physician and consultant
          - Increased risk of CVD
          - Lifestyle advice and primary prevention
  - Non-obstructive but significant CHD
    - Letter to primary care physician and consultant
      - Significant CHD
      - Lifestyle advice and secondary prevention
  - No significant CHD
    - Letter to patient, primary care physician and consultant
      - No evidence of significant CHD

The SCOT-HEART Trial

Recruiting and Imaging Centres

Complete Health Record Data Capture

12 Centers Across Scotland

Perth Royal Infirmary, Perth
Ninewells, Dundee
Victoria Hospital, Kirkcaldy
Forth Valley Hospital, Larbert
Western General Hospital, Edinburgh
Royal Infirmary, Edinburgh
St John’s Hospital, Livingston
Borders General Hospital, Melrose

Royal Alexandra Hospital, Paisley
Western Infirmary, Glasgow
Glasgow Royal Infirmary, Glasgow
University Hospital, Ayr

• 4,080 of 4,146 (98.4%) patients remained registered in Scotland.
• No patient withdrew consent
• Complete data over a median of 4.8 years comprising 20,254 patient-years of follow-up
<table>
<thead>
<tr>
<th></th>
<th>All Participants</th>
<th>Standard Care + CTCA</th>
<th>Standard Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>4146 (100%)</td>
<td>2073 (50%)</td>
<td>2073 (50%)</td>
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<tr>
<td>Male</td>
<td>2325 (56%)</td>
<td>1162 (56%)</td>
<td>1163 (56%)</td>
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<tr>
<td>Age (years)</td>
<td>57±10</td>
<td>57±10</td>
<td>57±10</td>
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<tr>
<td>Body-mass Index (kg/m²)</td>
<td>30±6</td>
<td>30±6</td>
<td>30±6</td>
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<tr>
<td>Atrial Fibrillation</td>
<td>84 (2%)</td>
<td>42 (2%)</td>
<td>42 (2%)</td>
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<tr>
<td>Prior Coronary Heart Disease</td>
<td>372 (9%)</td>
<td>186 (9%)</td>
<td>186 (9%)</td>
</tr>
<tr>
<td>Prior Cerebrovascular Disease</td>
<td>139 (3%)</td>
<td>91 (4%)</td>
<td>48 (2%)</td>
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<tr>
<td>Prior Peripheral Vascular Disease</td>
<td>53 (1%)</td>
<td>36 (2%)</td>
<td>17 (1%)</td>
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<tr>
<td>Current or Ex-smoker</td>
<td>2185 (53%)</td>
<td>1095 (53%)</td>
<td>1090 (53%)</td>
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<tr>
<td>Hypertension</td>
<td>1395 (34%)</td>
<td>712 (34%)</td>
<td>683 (33%)</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>444 (11%)</td>
<td>223 (11%)</td>
<td>221 (11%)</td>
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<tr>
<td>Hypercholesterolaemia</td>
<td>2176 (53%)</td>
<td>1099 (53%)</td>
<td>1077 (52%)</td>
</tr>
<tr>
<td>Family History</td>
<td>1716 (41%)</td>
<td>887 (43%)</td>
<td>829 (40%)</td>
</tr>
<tr>
<td>Serum Total Cholesterol (mmol/L)</td>
<td>5.41±1.20</td>
<td>5.41±1.23</td>
<td>5.41±1.17</td>
</tr>
<tr>
<td>Serum HDL-Cholesterol (mmol/L)</td>
<td>1.35±0.43</td>
<td>1.35±0.42</td>
<td>1.35±0.43</td>
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<tr>
<td></td>
<td>All Participants</td>
<td>Standard Care + CTCA</td>
<td>Standard Care</td>
</tr>
<tr>
<td>--------------------------------</td>
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<tr>
<td><strong>Anginal Symptoms</strong></td>
<td></td>
<td></td>
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<tr>
<td>Typical</td>
<td>1462 (35%)</td>
<td>737 (36%)</td>
<td>725 (35%)</td>
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<tr>
<td>Atypical</td>
<td>988 (24%)</td>
<td>502 (24%)</td>
<td>486 (23%)</td>
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<tr>
<td>Non-anginal</td>
<td>1692 (41%)</td>
<td>833 (40%)</td>
<td>859 (41%)</td>
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<tr>
<td><strong>Electrocardiogram</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Normal</td>
<td>3492 (84%)</td>
<td>1757 (85%)</td>
<td>1735 (84%)</td>
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<tr>
<td>Abnormal</td>
<td>608 (15%)</td>
<td>292 (14%)</td>
<td>316 (15%)</td>
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<td><strong>Stress Electrocardiogram</strong></td>
<td></td>
<td></td>
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<tr>
<td>Performed</td>
<td>3517 (85%)</td>
<td>1764 (85%)</td>
<td>1753 (85%)</td>
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<tr>
<td>Normal</td>
<td>2188 (62%)</td>
<td>1103 (63%)</td>
<td>1085 (62%)</td>
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<tr>
<td>Inconclusive</td>
<td>566 (16%)</td>
<td>284 (16%)</td>
<td>282 (16%)</td>
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<tr>
<td>Abnormal</td>
<td>529 (15%)</td>
<td>264 (15%)</td>
<td>265 (15%)</td>
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<tr>
<td><strong>Further Investigation</strong></td>
<td></td>
<td></td>
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</tr>
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<td></td>
<td>1315 (32%)</td>
<td>633 (31%)</td>
<td>682 (33%)</td>
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<tr>
<td><strong>Stress Imaging</strong></td>
<td></td>
<td></td>
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<td>Radionuclide</td>
<td>389 (9%)</td>
<td>176 (9%)</td>
<td>213 (10%)</td>
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<tr>
<td>Other</td>
<td>30 (1%)</td>
<td>16 (1%)</td>
<td>14 (1%)</td>
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<tr>
<td><strong>Invasive Coronary Angiography</strong></td>
<td>515 (12%)</td>
<td>255 (12%)</td>
<td>260 (13%)</td>
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<tr>
<td><strong>Predicted 10-year CHD Risk</strong></td>
<td>17±12%</td>
<td>18±11%</td>
<td>17±12%</td>
</tr>
</tbody>
</table>
Primary Clinical End Point

Hazard Ratio 0.59
(95% CI, 0.41 to 0.84)
P=0.004
Primary Clinical End Point

Excluding the 50-day treatment delay

*Hazard Ratio 0.53
(95% CI, 0.36 to 0.78)
P=0.001

JACC 2016;67:1759-1768
### Primary Clinical End Point

#### Subgroups of Interest

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No. of patients</th>
<th>CCTA</th>
<th>Standard Care</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value for Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All</strong></td>
<td>4146</td>
<td>48/2073 (2.3)</td>
<td>81/2073 (3.9)</td>
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<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt;65 years</td>
<td>3092</td>
<td>32/1538 (2.1)</td>
<td>51/1554 (3.3)</td>
<td>0.62 0.40, 0.98</td>
<td>0.675</td>
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<tr>
<td>≥65 years</td>
<td>1054</td>
<td>18/535 (3.0)</td>
<td>30/519 (5.8)</td>
<td>0.53 0.29, 0.98</td>
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<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Female</td>
<td>1821</td>
<td>11/611 (1.2)</td>
<td>22/910 (2.4)</td>
<td>0.50 0.24, 1.04</td>
<td>0.572</td>
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<tr>
<td>Male</td>
<td>2325</td>
<td>37/1162 (3.2)</td>
<td>59/1183 (5.1)</td>
<td>0.63 0.42, 0.95</td>
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<tr>
<td><strong>10-year Cardiovascular Risk</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt;15</td>
<td>2036</td>
<td>15/999 (1.5)</td>
<td>21/1067 (2.0)</td>
<td>0.78 0.40, 1.51</td>
<td>0.213</td>
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<tr>
<td>≥15</td>
<td>2110</td>
<td>33/1104 (3.0)</td>
<td>60/1006 (6.0)</td>
<td>0.50 0.33, 0.77</td>
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<tr>
<td><strong>NICE Classification</strong></td>
<td></td>
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<tr>
<td>Non-anginal</td>
<td>1447</td>
<td>8/712 (1.1)</td>
<td>18/735 (2.4)</td>
<td>0.45 0.19, 1.03</td>
<td>0.578</td>
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<tr>
<td>Possible angina</td>
<td>2323</td>
<td>27/1174 (2.3)</td>
<td>44/1149 (3.8)</td>
<td>0.60 0.37, 0.98</td>
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<tr>
<td><strong>Prior CHD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3774</td>
<td>35/1887 (1.9)</td>
<td>62/1887 (3.3)</td>
<td>0.57 0.37, 0.86</td>
<td>0.679</td>
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<tr>
<td>Yes</td>
<td>376</td>
<td>13/187 (7.0)</td>
<td>19/189 (10.1)</td>
<td>0.65 0.32, 1.32</td>
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<tr>
<td><strong>Diabetes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No</td>
<td>3702</td>
<td>41/1850 (2.2)</td>
<td>64/1852 (3.5)</td>
<td>0.63 0.43, 0.94</td>
<td>0.400</td>
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<tr>
<td>Yes</td>
<td>444</td>
<td>7/223 (3.1)</td>
<td>17/221 (7.7)</td>
<td>0.38 0.15, 0.87</td>
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</tbody>
</table>
Non-fatal Myocardial Infarction

Hazard Ratio 0.60
(95% CI, 0.41 to 0.87)
P=0.007
## Mortality

### Cardiovascular and Non-cardiovascular

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>All Participants</th>
<th>CCTA</th>
<th>Standard Care</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary Heart Disease</td>
<td>13 (0.3)</td>
<td>4 (0.2)</td>
<td>9 (0.4)</td>
<td>0.46 (0.14, 1.48)</td>
<td>0.193</td>
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<tr>
<td>Cardiovascular</td>
<td>17 (0.4)</td>
<td>5 (0.2)</td>
<td>12 (0.6)</td>
<td>0.43 (0.15, 1.22)</td>
<td>0.111</td>
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<tr>
<td>Non-cardiovascular</td>
<td>69 (1.7)</td>
<td>38 (1.8)</td>
<td>31 (1.5)</td>
<td>1.24 (0.77, 2.00)</td>
<td>0.368</td>
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<tr>
<td>All-cause</td>
<td>86 (2.1)</td>
<td>43 (2.1)</td>
<td>43 (2.1)</td>
<td>1.02 (0.67, 1.55)</td>
<td>0.936</td>
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</table>
Invasive Coronary Angiography and Coronary Revascularisation

Hazard ratio 1.00 (95% CI, 0.88 to 1.13)  
P=0.993

Hazard Ratio 1.07 (95% CI, 0.91 to 1.27)  
P=0.409

ESC Congress Munich 2018
Invasive Coronary Angiography and Coronary Revascularisation

Beyond One-Year (Post-hoc Analysis)

Hazard ratio 0.70
(95% CI, 0.52 to 0.95)
P=0.022

Hazard Ratio 0.59
(95% CI, 0.38 to 0.90)
P=0.015

Follow up (years)

No. at Risk
Standard Care 1674 1639 1616 1251 678
CCTA 1654 1625 1613 1258 656

Follow up (years)

No. at Risk
Standard Care 1885 1847 1834 1450 794
CCTA 1827 1815 1806 1426 771

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Munich 2018

Standard Care Alone
CTCA + Standard Care
Statin Therapy Use over 5 Years

The Right Patient Gets the Right Treatment

<table>
<thead>
<tr>
<th>Follow up (years)</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
</tr>
</tbody>
</table>

*P<0.0001

10-Year Cardiovascular Risk (ASSIGN SCORE)

Coronary Artery Disease on CTCA

No Coronary Artery Disease on CTCA

ESC Congress
Munich 2018
Coronary CT Angiography and the Future Risk of Myocardial Infarction

*The Right Patient Gets the Right Treatment*

- Coronary CT angiography leads to a reduction in 5-year coronary heart disease death or non-fatal myocardial infarction
- Early increases in invasive coronary angiography and coronary revascularisation are offset by lower rates beyond 1 year
- Benefits appear to be attributable to better targeted preventative therapies that persist out to 5 years
- Should coronary CT angiography be the non-invasive test of choice?
The SCOT-HEART Investigators

Royal Infirmary of Edinburgh, Edinburgh: Ms Barbara Allen, Prof Edwin van Beek, Dr Miles Behan, Miss Danielle Bertram, Mr David Brian, Ms Amy Cowan, Dr Nicholas Cruden, Dr Martin Denvir, Dr Marc Dweck, Ms Laura Flint, Dr Andrew Flapan, Miss Samantha Fyfe, Dr Neil Grubb, Mrs Collette Keanie, Dr Chris Lang, Dr Tom MacGillivray, Dr David MacLachlan, Miss Margaret MacLeod, Dr Saeed Mirsadrae, Mrs Avril Morrison, Dr Nicholas Mills, Dr David Northridge, Mrs Alyson Phillips, Miss Laura Queripel, Dr John Reid, Dr Neal Uren, Dr Nicholas Weir. St John’s Hospital, Livingston; Dr Ashok Jacob, Mrs Fiona Bett, Mrs Frances Divers, Ms Katie Fairley, Ms Edith Keegan, Ms Tricia White, Ms Julia Fowler. University Hospital, Ayr: Dr John Gemmill, Dr James McGowan, Mrs Margo Henry. Victoria Hospital, Kirkcaldy: Dr Mark Francis, Mr Dennis Sandeman Ms Lorraine Dinnen. Western General Hospital, Edinburgh: Prof David Newby Dr Peter Bloomfield, Dr Martin Denvir, Dr Peter Henriksen, Dr Donald MacLeod, Mrs Avril Morrison. Western Infirmary, Glasgow & Institute of Cardiovascular & Medical Sciences, University of Glasgow: Prof Colin Berry, Dr Kenneth Mangion, Dr Ify Mordi, Dr Giles Roditi, Dr Nikolaos Tzemos, Dr Eugene Connolly, Mrs Heather Boylan, Mrs Ammani Brown, Ms Lesley Farrell, Mrs Alison Frood, Ms Caroline Glover, Mrs Janet Johnstone, Mrs Tracey Steedman, Mrs Kirsten Lanaghan, Mrs Deborah McGlynn, Ms Lorraine McGregor, Ms Evonne McLennan, Ms Laura Murdoch, Miss Victoria Paterson, Ms Fiona Teyhan, Ms Marion Teenan, Ms Rosie Woodward. Borders General Hospital, Melrose: Dr Paul Neary Mrs Gillian Donaldson, Mr Terry Fairbairn, Mrs Marlene Fotheringham, Mrs Fiona Hall. Forth Valley Royal Hospital, Larbert: Dr Allister Hargreaves, Dr James Spratt, Dr Stephen Glen, Ms Sarah Perkins, Ms Fiona Taylor Mrs Louisa Cram, Ms Catherine Beveridge, Ms Avril Cairns, Ms Frances Dougherty. Glasgow Royal Infirmary: Dr Hany Eteiba, Dr Alan Rae, Ms Kate Robb, Ms Wenda Crawford, Ms Patricia Clarkin, Ms Elizabeth Lennon. Ninewells Hospital, Dundee: Prof. Graeme Houston, Prof Stuart Pringle, Dr Prasad Gunar Ramkumar, Dr Thiru Sudarshanan, Dr Yvonne Fogarty, Ms Dawn Barrie, Ms Kim Bissett, Dr Adelle Dawson, Mr Scott Dundas, Mrs Deborah Latham, Ms Linda O’Neill, Mrs Valerie Ritchie. Perth Royal Infirmary, Perth: Dr Hamish Dougall. Royal Alexandra Hospital, Paisley: Dr Faheem Ahmed, Dr Alistair Cormack, Dr Iain Findlay, Dr Stuart Hood, Dr Clare Murphy, Dr Eileen Peat, Ms Lynne McCabe, Ms Margaret McCubbin.
Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

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