Diagnosis of CAD using CT coronary angiography

P.J. de Feijter
As an aid to diagnosis in Ischaemic Heart Disease it seems, at present, to offer little that cannot be more easily obtained by much simpler methods such as good history taking and electrocardiography.
Guidelines on the management of stable angina pectoris: executive summary

The Task Force on the Management of Stable Angina Pectoris of the European Society of Cardiology

Recommendations for the use of CT angiography in stable angina
Class IIb

(1) Patients with a low pre-test probability of disease, with a non-conclusive exercise ECG or stress imaging test (level of evidence C)
### ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR Appropriateness Criteria

**Detection of CAD: Symptomatic—Evaluation of Chest Pain Syndrome (Use of CT Angiogram)**
- Intermediate pre-test probability of CAD
- ECG uninterpretable OR unable to exercise

**Detection of CAD: Symptomatic—Evaluation of Intra-Cardiac Structures (Use of CT Angiogram)**
- Evaluation of suspected coronary anomalies

**Detection of CAD: Symptomatic—Acute Chest Pain (Use of CT Angiogram)**
- Intermediate pre-test probability of CAD
- No ECG changes and serial enzymes negative

**Detection of CAD With Prior Test Results—Evaluation of Chest Pain Syndrome (Use of CT Angiogram)**
- Uninterpretable or equivocal stress test (exercise, perfusion, or stress echo)

**Structure and Function—Morphology (Use of CT Angiogram)**
- Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves
- Evaluation of coronary arteries in patients with new onset heart failure to assess etiology
64 Slice CT-CORONARY ANGIOGRAPHY

State of-the-art technology
MSCT APPLICATIONS in Stable Angina

- Detect or Rule out CAD
  
  ALTERNATIVE TEST

- Replacement inv. CA
  
  EXTENT LOCATION SEVERITY
### Diagnostic Performance of 64-slice CT-CA Multicenter Studies

**Patient based analysis**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Sens.%</th>
<th>Spec.%</th>
<th>PPV %</th>
<th>NPV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core 64</td>
<td>85</td>
<td>90</td>
<td>91</td>
<td>83</td>
</tr>
<tr>
<td>Accuracy</td>
<td>95</td>
<td>83</td>
<td>64</td>
<td>99</td>
</tr>
<tr>
<td>Dutch</td>
<td>99</td>
<td>64</td>
<td>86</td>
<td>97</td>
</tr>
<tr>
<td>Weighted</td>
<td>93</td>
<td>78</td>
<td>82</td>
<td>93</td>
</tr>
</tbody>
</table>

Core 64: excluded CACS >600 (89) and others (25)
Accuracy: excluded (15)
Dutch: excluded (11)

Miller NEJM 2008;359:2324
Budoff JACC 2008;52:1724
Meijboom JACC 2008;52:2135
64 Slice CT CA for patients with Stable Angina
Single- and Multi-center Studies
Pooled analysis: approx. 1750 pts

Neg. Predictive Value: 93% (83%-99%)

Reliable to Rule Out the Presence of Significant Coronary Stenosis
Replacement Invasive Coronary Angiography?

Very high sensitivity (FN ↓)

Very high specificity (FP ↓)

Specific lesion characteristics:
- bifurcation
- ostial
- calcific
### Diagnostic Performance of 64-slice CT-CA Dutch Multicenter Study

Patient, Vessel, Segment based analysis

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Prev.%</th>
<th>Sens.%</th>
<th>Spec.%</th>
<th>PPV %</th>
<th>NPV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>360</td>
<td>68</td>
<td>99</td>
<td>64</td>
<td>86</td>
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<tr>
<td>Vessels</td>
<td>1440</td>
<td>26</td>
<td>95</td>
<td>77</td>
<td>59</td>
<td>98</td>
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<tr>
<td>Segments</td>
<td>5297</td>
<td>9</td>
<td>88</td>
<td>90</td>
<td>47</td>
<td>99</td>
</tr>
<tr>
<td>LM, 3-VD</td>
<td>98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Meijboom JACC 2008;52:2135
Over/under-estimation of CTCA severity of diameter stenoses compared to QCA

Clustering of mismatch around 50%

Meyboom JACC 2008 52:2135
Calcium score: 0

Calcium score: 2870
64 Slice CT CA for patients with Stable Angina

Pooled analysis; 1481 pts

Pos. Predictive Value : 48% - 89%

Cannot (yet?) replace invasive CA
Dual Source 64 slice CT-CA vs Inv. CA

CT-CA  Inv. CA
Temporal resolution:  83 ms  12-20 ms
Spatial resolution   :  0.5 mm  0.2 mm
Diagnostic Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

Low <20%  Intermediate 20%-80%  High >80%

ECG stress

pos  neg

SPECT, Echo

normal  mild  mod, severe

Rx  Life style change  Optimal Rx  Inv CA / Revasc
## Detection of CAD

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity%</th>
<th>Specificity%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise ECG</td>
<td>68</td>
<td>77</td>
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<tr>
<td>Exercise Echo</td>
<td>80-85</td>
<td>84-86</td>
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<tr>
<td>Dob stress Echo</td>
<td>40-100</td>
<td>62-100</td>
</tr>
<tr>
<td>Vasodilator Echo</td>
<td>56-92</td>
<td>87-100</td>
</tr>
<tr>
<td>Exercise MPI</td>
<td>85-90</td>
<td>70-75</td>
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<tr>
<td>Dob stress MPI</td>
<td>86</td>
<td>90</td>
</tr>
<tr>
<td>Vasodilator MPI</td>
<td>89-91</td>
<td>89-91</td>
</tr>
<tr>
<td>MR perfusion</td>
<td>84</td>
<td>85</td>
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<tr>
<td>MR wall motion</td>
<td>89</td>
<td>84</td>
</tr>
<tr>
<td>CTCA</td>
<td>95</td>
<td>92</td>
</tr>
</tbody>
</table>
Which test comes first?

Anatomy

CT

Function

Exercise ECG
SPECT
Stress Echo
CMR
PET

Anatomy and Function

PET – CT
SPECT – CT
Diagnostic Work-up Stable Angina
ECG Stress Testing vs CT CA

rest

220 W
## PATIENT DEMOGRAPHICS

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>%</th>
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<tbody>
<tr>
<td><strong>N</strong></td>
<td>517</td>
<td></td>
</tr>
<tr>
<td><strong>Age (59 ± 10)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td>317</td>
<td>61</td>
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<tr>
<td><strong>Typical angina</strong></td>
<td>223</td>
<td>43</td>
</tr>
<tr>
<td><strong>Atypical angina</strong></td>
<td>111</td>
<td>22</td>
</tr>
<tr>
<td><strong>Nonanginal</strong></td>
<td>183</td>
<td>35</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>224</td>
<td>43</td>
</tr>
<tr>
<td><strong>High cholesterol</strong></td>
<td>242</td>
<td>47</td>
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<tr>
<td><strong>Smoker</strong></td>
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<td>13</td>
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<tr>
<td><strong>Family history CAD</strong></td>
<td>98</td>
<td>19</td>
</tr>
<tr>
<td><strong>Obesity</strong></td>
<td>101</td>
<td>20</td>
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</table>
## Pre-test probability of obstructive CAD

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Gender</th>
<th>Non-anginal chest pain</th>
<th>Atypical angina</th>
<th>Typical Angina</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-39</td>
<td>M</td>
<td>5</td>
<td>22</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>40-49</td>
<td>M</td>
<td>14</td>
<td>46</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3</td>
<td>13</td>
<td>55</td>
</tr>
<tr>
<td>50-59</td>
<td>M</td>
<td>22</td>
<td>59</td>
<td>92</td>
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<tr>
<td></td>
<td>F</td>
<td>8</td>
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<td>80</td>
</tr>
<tr>
<td>60-90</td>
<td>M</td>
<td>28</td>
<td>67</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>19</td>
<td>54</td>
<td>91</td>
</tr>
</tbody>
</table>

Diamond and Forrester, 1979
Pre-test probability
*Age, gender, type of chest pain
Cardiovascular risk factors (n= 517)*

- **Low Risk** <20% (n= 122)
- **Intermediate Risk** 20-80% (n= 249)
- **High Risk** >80% (n=146)

Stress testing (bicycle test or SPECT) and CT Coronary Angiography

Post-test probability
Pre-test probability of CAD, %

Low probability of CAD
No testing
Pre-test probability of CAD, %

High probability of presence of CAD
Direct referral to ICA
Pre-test probability of CAD, %

CAD ?????????
Non-invasive Testing

LEVEL OF UNCERTAINTY
Confirmation of CAD
Proceed to ICA
Post-test probability of CAD, %

Pre-test probability of CAD, %

LEVEL OF CERTAINTY

Exclusion of CAD
No further testing

- Test
LEVEL OF UNCERTAINTY

Post-test probability of CAD, %

Pre-test probability of CAD, %

Test result ???
2nd noninvasive test
Proceed to ICA
<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Probability Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low pre-test risk</td>
<td>&lt; 20%</td>
</tr>
<tr>
<td>Intermediate pre-test risk</td>
<td>20-80%</td>
</tr>
<tr>
<td>High pre-test risk</td>
<td>&gt; 80%</td>
</tr>
<tr>
<td>Probability</td>
<td>Pre-test Risk</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>&lt; 20%</td>
<td>Low</td>
</tr>
<tr>
<td>20-80%</td>
<td>Intermediate</td>
</tr>
<tr>
<td>&gt;80%</td>
<td>High</td>
</tr>
</tbody>
</table>

1. Stress test
2. CTCA

1. CTCA
2. Stress test
• Low pre-test risk: < 20%
• Intermediate pre-test risk: 20-80%
• High pre-test risk: > 80%

1. Stress test
2. CTCA

1. CTCA
2. Stress test

Clinical Utility of Stress test and CTCA, alone or combined
Low pre-test risk (<20%)
Low pre-test risk (<20%)

1. Stress test

Post-test probability (%)
Low pre-test risk (<20%)

1. Stress test

1. CTCA
Low pre-test risk (<20%)

1. Stress test
2. CTCA

Post-test probability (%)
Low pre-test risk (<20%)

1. Stress test
2. CTCA

1. CTCA
2. Stress test

Post-test probability (%)
Intermediate pre-test risk (20-80%)
Intermediate pre-test risk (20-80%)

1. Stress testing

Post-test probability (%)

- 23%
- 78%
Intermediate pre-test risk (20-80%)

1. Stress testing

- Post-test probability (%):
  - 23%
  - 78%

1. CTCA

- Post-test probability (%):
  - 1%
  - 93%
Intermediate pre-test risk (20-80%)

1. Stress testing
2. CTCA

1. CTCA
2. X
Intermediate pre-test risk (20-80%)

1. Stress testing
2. CTCA

1. CTCA
2. X

Post-test probability (%)
High pre-test risk (>80%)

Before testing

Direct referral to ICA

Pre-test probability of CAD, %

0 90 100

91%
1. Stress test
2. CTCA

LOW

Post-test probability (%)
1. Stress test
2. CTCA

1. CTCA
2. X
CONCLUSION

Pre-test probability
Age, gender
Type of chest pain
Cardiovascular risk factors

Low Risk <20% (n = 122)
Stress testing (bicycle test or SPECT)

Intermediate Risk 20-80% (n = 249)
CT Coronary Angiography

High Risk >80% (n = 146)
No noninvasive testing
Diagnostic Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

Low <20%  Intermediate 20%-80%  High >80%

ECG stress

CT CA

SPECT, Echo

pos

neg

pos

neg

neg, mild

mod, severe

mild, neg

Lifestyle  Discharge  Rx  Inv CA / Revasc  Rx
Indications and value of coronary angiography

F. Mason Sones, Jr. Circulation december 1972

1) “… selective coronary arteriography has been most useful in excluding the presence of coronary atherosclerosis in a large number of patients with chest pain or nonspecific ECG changes that had been mistakenly attributed to the presence of significant coronary heart disease by their physicians…”

2) “… when adequately performed and interpreted, coronary angiography reveals the exact location and relative severity of obstructive lesions in visible branches of the coronary arteries…”
Diagn Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

Low <20%  Intermediate 20%-80%  High >80%

ECG stress

CT CA

neg  neg or <10%  >10%

RCA   LM LAD  SPECT, Echo

LCx   3 VD

Discharge  Lifestyle  Optimal Rx  Inv CA / Revasc
Take Home Message

- CT CA is reliable to RULE OUT CAD
- CT CA cannot replace inv. CA
- Evolving CT role in the diagnostic workup of patients with stable angina
- Rapid Evolving Technology
- Imagers should become involved with CT CA
Low Diagnostic Yield of Elective Coronary Angiography

398,978 patients, median age 61 yrs, stable chest pain without known CAD

Men 53%, diabetes 26%, hypertension 70%
Non-invasive testing 84%

No symptoms 30% atypical ap 37% stable ap 33%

No CAD (<20%) 39.2%
Non-obstr. CAD (20-70%) 32.2%
Obstr. CAD (>70%) 37.6%
Obstr. CAD (>50%) 41%

Patel NEJM 2010;362:886
Diagnostic Work-up Stable Angina Stress Testing vs CT CA

Patients: 517

Duke Risk Score: age, gender, RF, and chest pain

Low <20%  Interm. 20-80%  High >80% Pre-test Risk

rest  220 W
<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Intermediate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Test Risk</td>
<td>&lt; 20%</td>
<td>20%-80%</td>
<td>&gt;80%</td>
</tr>
</tbody>
</table>

**Assumption**

<table>
<thead>
<tr>
<th>Post Test Risk</th>
<th>5%-90%</th>
<th>further tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;5% or &gt;90%</td>
<td>no further tests</td>
</tr>
</tbody>
</table>
Low pre-test probability 11%

N 122

ECG Stress Test

Pos 34
32%

Neg 88
4%

CT CA

Pos 25
81%

Neg 9
0%

Post test probability

No further tests
Low pre-test probability 11%

N 122

CT CA

Pos 35

Neg 87

Post test prob. 52%

↓

ECG Stress Test

Pos 25

Neg 10

Post test prob. 81% 27%

No further tests
Intermediate pre-test probability 50%

ECG Stress Test

N 249

Pos 131
Neg 118

78%
23%

CT CA

Pos 110
Neg 21
Pos 28
Neg 90

98%
3%
83%
0%

Post test probability
Intermediate pre-test probability 50%

N 249

CT CA

Pos 138

94%

Neg 111

1%

Post test probability

No further tests

No further tests
High pre-test probability 91%

N 146

ECG Stress Test

Pos 105
Neg 41

95% 81%

No further tests

CT CA

Pos 28
Neg 13

94% 6%
High pre-test probability 91%

CT CA

N 146

Pos 127

97%

Neg 19

No further tests

Post test probability 97%

ECG Stress Test

Pos 6

17%

Neg 13

6%

Post test probability 12%
**MSCT: INDICATIONS**

- Detect or Rule out CAD
  
  **ALTERNATIVE TEST**

- Replacement inv. CA
  
  **EXTENT, LOCATION, SEVERITY**
MSCT bypass grafts

LIMA-LAD anastomosis

LAD run-off
DS-MSCT

LIMA anastomose
LAD and Diag 1
<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Sens. %</th>
<th>Spec. %</th>
<th>PPV %</th>
<th>NPV %</th>
</tr>
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<tbody>
<tr>
<td>Graft segments</td>
<td>182</td>
<td>99</td>
<td>96</td>
<td>95</td>
<td>99</td>
</tr>
<tr>
<td>Distal cor.run-off</td>
<td>123</td>
<td>89</td>
<td>93</td>
<td>50</td>
<td>99</td>
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<tr>
<td>Non-grafted segm.</td>
<td>288</td>
<td>97</td>
<td>86</td>
<td>66</td>
<td>99</td>
</tr>
</tbody>
</table>

Diagnostic performance
64 CT-angiography after CABG
(N = 52)

Malagutti EHJ 2006
Vascular access
Definition of the valve plane
Annulus diameters

23mm

27mm

Mean diameter = 25mm
Coronary Bypass Grafts
Non-invasive assessment of CAD: Which Patients?

- Sensitivity 75%
- Specificity 75%
Non-invasive assessment of CAD: Which Patients?

Pre-test probability of CAD, %

Post-test probability of CAD, %

Intermediate probability

+ TEST

- TEST
Non-invasive assessment of CAD: Which Patients?

Pre-test probability of CAD, %
Post-test probability of CAD, %

High probability

+ TEST
- TEST

0 80
Pre-test probability of CAD, %

57 92
Non-invasive assessment of CAD: Which Patients?

Pre-test probability of CAD, %
Post-test probability of CAD, %

- TEST
+ TEST

Low probability

Pre-test probability of CAD, %

0 20 43 8
### 64-slice CT in 254 symptomatic patients

<table>
<thead>
<tr>
<th>Pre-test probability</th>
<th>N pat</th>
<th>Sens %</th>
<th>Spec %</th>
<th>PPV %</th>
<th>NPV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>105</td>
<td>98</td>
<td>74</td>
<td>93</td>
<td>89</td>
</tr>
<tr>
<td>Intermediate</td>
<td>83</td>
<td>100</td>
<td>84</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
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<td>66</td>
<td>100</td>
<td>93</td>
<td>75</td>
<td>100</td>
</tr>
</tbody>
</table>

\[P: \text{ns} \quad P: 0.03\]
CTCA in the high pre-test probability group

Post-test probability of CAD, %

Pre-test probability of CAD, %

CTCA +
CTCA -

Does not provide additional information

Most patients referred for diagn. CCA
CTCA in low, intermediate pre-test probability group

Post-test probability of CAD, %

0 30 70 100
Low Intermediate High

Pre-test probability of CAD, %

CTCA +
CTCA -

Positive scan warrants further investigation with CCA (or functional test)
CTCA in low, intermediate pre-test probability group

Pre-test probability of CAD, %

Low 30 Intermediate 70 High

Post-test probability of CAD, %

CTCA +
CTCA -

Rules out sign. CAD
No further downstream diagnostic tests
## Detection of CAD

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Sensitivity%</th>
<th>Specificity%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise ECG</td>
<td>68</td>
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Stress Testing vs CT CA

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rest  220 W
MSCT: INDICATIONS

- Detect or Rule out CAD
  - ALTERNATIVE TEST
- Replacement inv. CA
  - EXTENT LOCATION SEVERITY
NOT PATIENT ANALYSIS

Per segment analysis!

INVASIVE QCA vs MSCT CA
Diagnostic Accuracy 64-slice CT-Coronary Angiography (patients/segments 1251/17695; prevalence CAD: 19%)

Per segment - analysis

- Non-evaluable patients: 4.0%
- Sensitivity: 86%
- Specificity: 96%
- PPV: 83%
- NPV: 96.5%

Abdulla EHJ 2007;28:3042
# Diagnostic Performance of 64-slice CT-CA Multicenter Studies

## Vessel based analysis

<table>
<thead>
<tr>
<th>Vessel</th>
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<td>93</td>
<td>82</td>
</tr>
<tr>
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<td>84</td>
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<td>51</td>
</tr>
<tr>
<td>Dutch</td>
<td>1440</td>
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Budoff JACC 2008;52:1724  
Meijboom JACC 2008;52:2135
Replacement Invasive Coronary Angiography?

- Very high sensitivity (FN ↓)
- Very high specificity (FP ↓)
- Specific lesion characteristics:
  - bifurcation
  - ostial
  - calcific
<table>
<thead>
<tr>
<th>Indication</th>
<th>Appropriateness Criteria (Median Score)</th>
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| 2. Intermediate pre-test probability of CAD  
  ECG uninterpretable OR unable to exercise                                                                                                           | A (7)                                  |
| **Detection of CAD: Symptomatic—Evaluation of Intra-Cardiac Structures (Use of CT Angiogram)**                                                                                                               |                                        |
| 4. Evaluation of suspected coronary anomalies                                                                                                                                                                | A (9)                                  |
| **Detection of CAD: Symptomatic—Acute Chest Pain (Use of CT Angiogram)**                                                                                                                                     |                                        |
| 6. Intermediate pre-test probability of CAD  
  No ECG changes and serial enzymes negative                                                                                                           | A (7)                                  |
| **Detection of CAD With Prior Test Results—Evaluation of Chest Pain Syndrome (Use of CT Angiogram)**                                                                                                           |                                        |
| 16. Uninterpretable or equivocal stress test (exercise, perfusion, or stress echo)                                                                                                                                 | A (8)                                  |
| **Structure and Function—Morphology (Use of CT Angiogram)**                                                                                                                                                 |                                        |
| 28. Assessment of complex congenital heart disease including anomalies of coronary circulation, great vessels, and cardiac chambers and valves                                                                 | A (7)                                  |
| 29. Evaluation of coronary arteries in patients with new onset heart failure to assess etiology                                                                                                                | A (7)                                  |
| **Structure and Function—Evaluation of Intra- and Extra-Cardiac Structures (Use of Cardiac CT)**                                                                                                            |                                        |
| 33. Evaluation of cardiac mass (suspected tumor or thrombus)  
  Patients with technically limited images from echocardiogram, MRI, or TEE                                                                 | A (8)                                  |
| 34. Evaluation of pericardial conditions (pericardial mass, constrictive pericarditis, or complications of cardiac surgery)  
  Patients with technically limited images from echocardiogram, MRI, or TEE                                                                         | A (8)                                  |
<p>| 35. Evaluation of pulmonary vein anatomy prior to invasive radiofrequency ablation for atrial fibrillation                                                                                                   | A (8)                                  |
| 36. Noninvasive coronary vein mapping prior to placement of biventricular pacemaker                                                                                                                        | A (8)                                  |
| 37. Noninvasive coronary arterial mapping, including internal mammary artery prior to repeat cardiac surgical revascularization                                                                            | A (8)                                  |
| <em><em>Structure and Function—Evaluation of Aortic and Pulmonary Disease (Use of CT Angiogram</em>)</em>*                                                                                                                  |                                        |
| 38. Evaluation of suspected aortic dissection or thoracic aortic aneurysm                                                                                                                                     | A (9)                                  |
| 39. Evaluation of suspected pulmonary embolism                                                                                                                                                              | A (9)                                  |</p>
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Hendel, JACC’06
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Diagn Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

Low <20%  Intermediate 20%-80%  High >80%

SPECT  Inv CA  Revascularisation

ECG stress  CT CA

neg  neg  neg or <10%

RCA  LM LAD

LCx  3 VD  >10%

SPECT, Echo

Discharge  Lifestyle  Optimal Rx  Inv CA / Revasc
Diagn Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

- Low <20%
  - SPECT

- Intermediate 20%-80%
  - ECG stress
    - neg
      - Discharge
    - pos
      - Lifestyle

- High >80%
  - CT CA
    - neg
      - Optimal Rx
    - pos
      - SPECT, ECHO
        - neg, mild
        - mod, severe
      - Inv CA / Revasc
Diagn. Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

Low <20%  Intermediate 20%-80%  High >80%

ECG stress

- neg
  - Discharge

- pos
  - Lifestyle

CTCA

- neg
  - Optimal Rx
- pos
  - Invasive CA
    - 1,2 VD
    - LM, 3 VD
  - Revascularization
Diagn Work-up in pts with stable chest pain

Age, gender, type ap, risk factors

Low <20%

ECG stress

neg

Discharge

pos

Lifestyle

Intermediate 20%-80%

SPECT, Echo

neg

Optimal Rx

mild

High >80%

mod. severe

Inv CA / Revasc

Optimal Rx
Clinical Utility of Stress Testing and CT Coronary Angiography in the Diagnosis of Obstructive Coronary Artery Disease

A.C. Weustink, P.J. de Feyter
Department of Radiology and Cardiology
Overall Diagnostic Performance of stress test and CTCA

<table>
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<tr>
<th></th>
<th>Sens %</th>
<th>Spec %</th>
<th>PPV %</th>
<th>NPV %</th>
<th>+ LR</th>
<th>- LR</th>
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<tr>
<td>STRESS TEST</td>
<td>78</td>
<td>77</td>
<td>80</td>
<td>76</td>
<td>3.5</td>
<td>0.28</td>
</tr>
<tr>
<td>64-CTCA</td>
<td>99</td>
<td>89</td>
<td>91</td>
<td>99</td>
<td>9.2</td>
<td>0.01</td>
</tr>
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Weustink et al., accepted Ann Int Med, 2010
Positive Likelihood Ratio (LR)
Negative Likelihood Ratio (LR)
Figure 2: Intention-to-diagnose strategies in patients with a low pre-test probability (<20%) *

Low risk (n=122)
Prev 20% (13-27)
Pre-test probability 11% (8-12)

Stress test
CTCA

Pos (n=34)
TP 17 FP 17
Prev 50% (34-66)
PTP 32% (23-37)

Neg (n=88)
TN 81 FN 7
Prev 8% (4-16)
PTP 4% (4-5)

CTCA
CTCA

Pos (n=35)
TP 24 FP 11
Prev 69% (53-84)
PTP 52% (47-57)

Neg (n=87)
TN 87 FN 0
Prev 0%
PTP 0%

Pos (n=25)
TP 17 FP 8
Prev 68% (48-83)
PTP 81% (77-85)

Neg (n=9)
TN 9 FN 0
Prev 0%
PTP 0%

Pos (n=10)
TP 7 FP 3
Prev 70% (49-89)
PTP 27% (20-34)

Neg (n=78)
TN 78 FN 0
Prev 0%
PTP 0%

Pos (n=25)
TP 17 FP 8
Prev 68% (50-86)
PTP 81% (77-85)

Neg (n=10)
TN 3 FN 7
Prev 70% (42-98)
PTP 27% (20-34)

Pos (n=9)
TP 0 FP 9
Prev 0%
PTP 0%

Neg (n=78)
TN 78 FN 0
Prev 0%
PTP 0%

* based on the Duke Clinical Score. N indicates number; CTCA, computed tomography coronary angiography; TP, true positive; TN, true negative; FP, false positive; FN, false negative; Pos, positive; Neg, negative; PTP, post-test probability; Prev, prevalence. Values in parentheses represent 95% confidence intervals.
Figure 3: Intention-to-diagnose strategies in patients with an intermediate pre-test probability (20-80%)*

Intermediate risk (n=249)
Prev 53% (46-59)
Pre-test probability 50% (48-52)

- Stress test
  - Pos (n=131)
    - TP 104 FP 27
    - Prev 79% (72-85)
    - PTP 78% (76-80)
    - CTCA
      - Pos (n=110)
        - TP 103 FP 7
        - Prev 90% (86-95)
        - PTP 96% (96-97)
      - Neg (n=21)
        - TN 20 FN 1
        - Prev 7% (2-17)
        - PTP 6% (3-8)
  - CTCA
    - Neg (n=118)
      - TN 91 FN 27
      - Prev 23% (16-31)
      - PTP 23% (20-25)
    - Pos (n=138)
      - TP 130 FP 8
      - Prev 94% (89-97)
      - PTP 93% (92-93)
      - CTCA
        - Pos (n=110)
          - TP 103 FP 7
          - Prev 94% (87-97)
          - PTP 98% (97-98)
          - Stress test
            - Neg (n=28)
              - TN 1 FN 27
              - Prev 96% (82-99)
              - PTP 77% (70-83)
              - CTCA
                - Pos (n=21)
                  - TP 1 FP 20
                  - Prev 5% (1.23)
                  - PTP 3% (2.5)
                  - Neg (n=90)
                    - TN 90 FN 0
                    - Prev 0%
                    - PTP 0%
        - Neg (n=111)
          - TN 110 FN 1
          - Prev 1% (0.5)
          - PTP 1% (1.1)
          - Stress test
            - Neg (n=90)
              - TN 90 FN 0
              - Prev 0%
              - PTP 0%

* based on the Duke Clinical Score. N indicates number; CTCA, computed tomography coronary angiography; TP, true positive; TN, true negative, FP, false positive; FN, false negative; Pos, positive; Neg, negative; PTP, post-test probability; Prev, prevalence. Values in parentheses represent 95% confidence intervals.
Figure 4: Intention-to-diagnose strategies in patients with a high risk pre-test probability (>80%) *

High risk (n=146)
Prevalence 83% (77-89)
Pre-test probability 91% (90-92)

- Stress test
  - Pos (n=105)
    - TP 95 FP 10
    - Prevalence 91% (83-95)
    - PTP 95% (94-95)
    - CTCA
  - Neg (n=41)
    - TN 15 FN 26
    - Prevalence 63% (48-76)
    - PTP 81% (78-84)
    - CTCA

- CTCA
  - Pos (n=127)
    - TP 120 FP 7
    - Prevalence 95% (91-98)
    - PTP 97% (97-98)
    - Stress test
  - Neg (n=19)
    - TN 18 FN 1
    - Prevalence 5% (1-25)
    - PTP 12% (7-17)
    - Stress test

- CTCA
  - Pos (n=99)
    - TP 54 FP 5
    - Prevalence 95% (89-98)
    - PTP 99% (98-99)
    - CTCA
  - Neg (n=6)
    - TN 9 FN 1
    - Prevalence 17% (3-56)
    - PTP 17% (6-29)
    - Stress test
  - Pos (n=28)
    - TP 26 FP 2
    - Prevalence 93% (77-98)
    - PTP 94% (93-96)
    - Neg (n=13)
      - TN 13 FN 0
      - Prevalence 0%
      - PTP 6% (2-9)
      - Stress test
  - Pos (n=99)
    - TP 94 FP 5
    - Prevalence 95% (89-98)
    - PTP 99% (98-99)
    - CTCA
  - Neg (n=28)
    - TN 2 FN 26
    - Prevalence 93% (77-98)
    - PTP 94% (93-96)
    - Stress test
  - Pos (n=6)
    - TP 1 FP 5
    - Prevalence 17% (3-56)
    - PTP 17% (6-29)
    - Neg (n=13)
      - TN 13 FN 0
      - Prevalence 0%
      - PTP 6% (2-9)

* Based on the Duke Clinical Score. N indicates number; CTCA, computed tomography coronary angiography; TP, true positive; TN, true negative; FP, false positive; FN, false negative; Pos, positive; Neg, negative; PTP, post-test probability; Prevalence. Values in parentheses represent 95% confidence intervals.
CTCA for detection and exclusion of significant CAD

• All studies analyzed small cohorts of highly selected pts
• No outcome-based studies using CTCA available
• However, all studies demonstrated a high NPV

...”CTCA can be used to exclude significant CAD”...
CTCA is an alternative to other tests, depending on local expertise and patients’ specific clinical history.

CTCA is NOT a substitute for stress testing.

Decision making strategy should be based on history / risk / symptoms and functional significance of coronary stenosis.

CTCA is reasonable in symptomatic pts (Class IIb)
CTCA is not recommended in asymptomatic individuals (Class IIIc)

Budoff MJ, Circulation’06
1. Pts with low / intermediate risk of having CAD not suitable for stress testing
2. Pts with low / intermediate risk of having CAD with ambiguous / discordant stress tests or discordant symptoms
3. Pts with ACP and negative / non diagnostic ECG and negative troponins at time of admission
4. Pts suspected of dilated cardiomyopathy to rule out ischemic heart disease
5. Pre-operative screening prior to non-coronary cardiac surgery
BAYES THEOREM

Post-test probability of disease, %

Pre-test probability of disease, %

low 20 intermediate 80 high 100

[Diagram showing the relationship between pre-test and post-test probability of disease]
BAYES THEOREM

Post-test probability of disease, %

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<tbody>
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Graph showing the relationship between pre-test probability of disease and post-test probability of disease.
BAYES THEOREM

Post-test probability of disease, %

Pre-test probability of disease, %

low 20 intermediate 80 high 100

+ Test

- Test