Introduction to Cardiac Calcium Scans and Cardiac CTA

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“His Master’s Voice,” by Francis Barraud (1856-1924)
A perplexing new technology

Originally named The Gramophone Company based in London.

Formed EMI (Electrical & Musical Industries) in 1931 after merging with the Columbia Gramophone Company.

Title: Kennedy Airport: The Beatles wave to the thousands of screaming teenagers after their arrival

https://www.loc.gov/pictures/item/94505316/
In 1967 he wondered if it might be possible "to determine what was in a box by taking readings at all angles through it."

Achievable using finely collimated X-ray beams.

Hounsfield went on to develop the principles of CT and three-dimensional reconstruction.

In his initial experiments using a gamma source it took 9 days to acquire the data and 2.5 hours to reconstruct the image on a large main frame computer.

Replacing the gamma ray source with an X-ray tube reduced the scanning time to 9 hours (A current cardiac CT is acquired in under 10 seconds).
WHAT IMPROVEMENTS SHOULD WE EXPECT TO SEE IN THE FUTURE?

Various attempts have been made to achieve useful pictures of the heart.

The time available for taking a picture of the heart is obviously longer than one heart beat. Some experiments were conducted some time ago using conventional CT machines but in which the traverse of the detectors was synchronised to the heart beat via an electro-cardiograph, passing over the heart in diastole (when the heart movement is at a minimum). Fig. 14 shows a picture from the experiment.

The heart chambers can be discerned by a little intravenous injected contrast media.

Another approach is being made at the Mayo clinic, Rochester, America, where a large machine is being constructed with 27 X-ray tubes designed to fire sequentially. It is hoped to take a sequence of pictures in a fraction of a second during one heart beat. However, the complexity and cost may rule out such a machine being used world-wide.

A further promising field may be the detection of the coronary arteries. It may be possible to detect these under special conditions of scanning.

Fig. 14. Scanning of the heart with detectors synchronised to the heart-beat passing over the heart in diastole. (The line artefacts are streaks caused by the wire of a pace-maker).
Multislice CT (MSCT)

Instead of a single-detector row, simultaneous acquisition of several slices is made via parallel detector rows.

100’s of detectors per row (slab)

# “rows”
(Average length of the heart 120mm)
Coronary Artery Calcium

The presence of calcium in the coronary arteries is invariably an indication of atherosclerosis.
(Am J Cardiol 1979;44:141-7)

A pathologic process of unhealthy arterial aging, not an inevitable consequence of aging. Healthy arterial aging (zero CAC) is possible.
(J Am Coll Cardiol Img 2015;8:1393–400)

Postmortem studies correlate the extent of coronary calcification with the severity of stenosis and the frequency of myocardial infarction.
(Radiology 1968;91:109-15)
A consistent relationship to CAC and the amount of overall plaque has been demonstrated during histopathologic study.

(Circulation. 1995;92:2157-2162)

Luminal stenosis is a late finding in atherosclerosis, and thus CAC scans allow for earlier detection of disease.
Quantification of Coronary Artery Calcium Using Ultrafast Computed Tomography

ARTHUR S. AGATSTON, MD, FACC, WARREN R. JANOWITZ, MD, FRANK J. HILDNER, MD, FACC, NOEL R. ZUSMER, MD, MANUEL VIAMONTE, JR., MD, ROBERT DETRANO, MD, PhD

Miami Beach, Florida and Long Beach, California
Lesions greater than 130 Hounsfield units

Area of at least 3 adjacent pixels (at least 1mm²).

Lesion density assigned score based on Hounsfield units.

Original calcium score (Agatston score) determined by the product of the calcified plaque area and the maximal calcium lesion density.

Detection, localization and quantification of CAD.

**Coronary calcification score determination.** To determine the presence and quantity of coronary calcium, each of the 20 levels was evaluated sequentially. The threshold for a calcific lesion was set at a computed tomographic density of 130 Hounsfield units having an area ≥1 mm². This eliminated single pixels with a computed tomographic density >130 units due to noise. At each level, all pixels with a computed tomographic density ≥130 units were displayed. A “region of interest” was placed around all lesions found within a coronary artery. Automated measurements of the lesion area in square millimeters and the maximal computed tomographic number of each region of interest were recorded.

A lesion score was determined based on the maximal computed tomographic number in the following manner: 1 = 130 to 199, 2 = 200 to 299, 3 = 300 to 399 and 4 ≥400 Hounsfield units. A score for each region of interest was calculated by multiplying the density score and the area. A total coronary calcium score was determined by adding up each of these scores for all 20 slices. The readers of the ultrafast computed tomographic scores were blinded to the
CAC Scan Examples

**Figure 1** Examples of Coronary Artery Scans

![Normal Scan](image1)

![Moderate Calcification](image2)

![Severe Calcification](image3)

(Left) Normal scan without calcified plaque. (Middle) Moderate calcified plaque in the left anterior descending and left circumflex coronary arteries. (Right) Severe calcified plaque involving the left main, left anterior descending, and left circumflex coronary arteries. Reprinted with permission from Hecht and Narula (12).
Now I have a calcium score…

Now what?

1. You have identified coronary artery calcium, so you have diagnosed coronary atherosclerosis.
2. You have also quantified the coronary artery calcium.
3. Does this correlate to clinical risk?
Coronary Calcium as a Predictor of Coronary Events in Four Racial or Ethnic Groups

Robert Detrano, M.D., Ph.D., Alan D. Guerci, M.D., J. Jeffrey Carr, M.D., M.S.C.E., Diane E. Bild, M.D., M.P.H., Gregory Burke, M.D., Ph.D., Aaron R. Folsom, M.D., Kiang Liu, Ph.D., Steven Shea, M.D., Moyses Szklo, M.D., Dr.P.H., David A. Bluemke, M.D., Ph.D., Daniel H. O’Leary, M.D., Russell Tracy, Ph.D., Karol Watson, M.D., Ph.D., Nathan D. Wong, Ph.D., and Richard A. Kronmal, Ph.D.
Coronary Calcium for Risk Assessment?

MESA (Multi-ethnic Study of Atherosclerosis)

Prospective population cohort registry

6,814 men and women followed for 3.8 years in the initial report

- 38.6% were white
- 27.6% were black
- 21.9% were Hispanic
- 11.9% were Chinese

https://www.mesa-nhlbi.org/CACReference.aspx
Warranty of Zero CAC?

Exclusively non-calcified plaques are present in 4% of asymptomatic patients. (*This is a screening test*)

Multiple studies have shown annual event rates of 0.11 to 0.12% in patients with zero CAC.

Absence of calcified plaque conveys a very low ten-year risk regardless of number of risk factors (1.1-1.7%).

<table>
<thead>
<tr>
<th>CAC Score</th>
<th>FRS Equivalent</th>
<th>10-Year Event Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Very low</td>
<td>1.1-1.7</td>
</tr>
<tr>
<td>1-100</td>
<td>Low</td>
<td>2.3-5.9</td>
</tr>
<tr>
<td>101-400</td>
<td>Intermediate</td>
<td>12.8-16.4</td>
</tr>
<tr>
<td>&gt;400</td>
<td>High</td>
<td>22.5-28.6</td>
</tr>
<tr>
<td>&gt;1,000</td>
<td>Very high</td>
<td>37.0</td>
</tr>
</tbody>
</table>

CAC = coronary artery calcium; FRS = Framingham Risk Score.
(Left) CAC progression of <15% per year is associated with a benign prognosis irrespective of the baseline CAC, implying stabilization of the atherosclerotic process. (Right) CAC progression of >15% per year is associated with a poor prognosis directly related to the baseline CAC, implying new plaque formation and inadequacy of treatment. CAC = coronary artery calcium; MI = myocardial infarction. Reprinted with permission from Raggi et al. (59).
# Proposed Decision-Making Approach to Selective Use of Coronary Artery Calcium Measurement for Risk Prediction

## Using 10-year ASCVD risk estimate plus coronary artery calcium (CAC) score to guide statin therapy

<table>
<thead>
<tr>
<th>Patient's 10-year atherosclerotic cardiovascular disease (ASCVD) risk estimate:</th>
<th>&lt;5%</th>
<th>5-7.5%</th>
<th>&gt;7.5-20%</th>
<th>&gt;20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consulting ASCVD risk estimate alone</td>
<td>Statin not recommended</td>
<td>Consider for statin</td>
<td>Recommend statin</td>
<td>Recommend statin</td>
</tr>
<tr>
<td>Consulting ASCVD risk estimate + CAC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If CAC score =0</td>
<td>Statin not recommended</td>
<td>Statin not recommended</td>
<td>Statin not recommended</td>
<td>Recommend statin</td>
</tr>
<tr>
<td>If CAC score &gt;0</td>
<td>Statin not recommended</td>
<td>Consider for statin</td>
<td>Recommend statin</td>
<td>Recommend statin</td>
</tr>
<tr>
<td>Does CAC score modify treatment plan?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAC not effective for this population</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAC can reclassify risk up or down</td>
<td></td>
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<tr>
<td>CAC can reclassify risk up or down</td>
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<td>CAC not effective for this population</td>
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</table>


The figure shows a modified approach to the guideline-based decision-making by incorporating a consideration of coronary artery calcium (CAC) testing to reclassify a patient’s risk up or down where it would make a clinically important change in the clinical decision. Adapted with permission from Nasi et al. (90).
Cardiac Computed Tomography Angiography (CTA)

- Addition of IV contrast.
- Contrast bolus is timed to be in the left heart at the time of image acquisition.
- Oral or IV beta blockers used for heart rate control.
- SL nitroglycerin is given to improve visualization of the coronary arteries.
Optimal Patient Requirements

- Low and stable heart rate (optimal less than 60 bpm).
- Minimal or low coronary calcium.
- BMI < 40.
- Able to lie flat on a CT scanner and raise arms above the head.
- Hold breath for at least ten seconds and follow breathing instructions.
- Good IV access 18g AC (20g minimum).
Gating
Scans gone bad

- Calcium
- Obesity
- Respiratory motion
- Elevated heart rate
- Ectopy and arrhythmias
Diagnostic Performance of 64-Multidetector Row Coronary Computed Tomographic Angiography for Evaluation of Coronary Artery Stenosis in Individuals Without Known Coronary Artery Disease

Results From the Prospective Multicenter ACCURACY (Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography) Trial

Matthew J. Budoff, MD,* David Dowe, MD,† James G. Jollis, MD,‡ Michael Gitter, MD,§ John Sutherland, MD,¶ Edward Halamert, MD,‖ Markus Scherer, MD,# Raye Bellinger, MD,* Arthur Martin, MD,†† Robert Benton, MD,‡‡ Augustin Delago, MD,‡‡ James K. Min, MD§§

Terrance and Sacramento, California; Atlantic City, New Jersey; Durham and Concord, North Carolina; Appleton, Wisconsin; Phoenix, Arizona; Indianapolis, Indiana; Hattiesburg, Mississippi; and Albany and New York, New York
ACCURACY Trial

- Multicenter: 16 clinical sites
- 64 MDCT
- 230 patients referred for invasive coronary angiography (ICA) were screened for a research CCTA prior to ICA.
- Strong negative predictive value: 99%.

- All patients who were found to have >70% stenosis by QCA were identified in ACCURACY to have at least a 50% visual narrowing by CCTA. In other words a report indicating no stenosis > 50% on the CCTA was 100% predictive of the absence of a 70% by QCA. (JACC Vol. 52, No. 21, November 18, 2008:1733–5)
The CT-STAT (Coronary Computed Tomographic Angiography for Systematic Triage of Acute Chest Pain Patients to Treatment) Trial

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Royal Oak and Detroit, Michigan; Tucson, Arizona; Giessen, Germany; Los Angeles, California; Boston, Massachusetts; Minneapolis, Minnesota; Chicago, Illinois; Atlanta, Georgia; and Fort Lauderdale, Florida

Objectives
The purpose of this study was to compare the efficiency, cost, and safety of a diagnostic strategy employing early coronary computed tomographic angiography (CCTA) to a strategy employing rest-stress myocardial perfusion imaging (MPI) in the evaluation of acute low-risk chest pain.

Background
In the United States, >8 million patients require emergency department evaluation for acute chest pain annually at an estimated diagnostic cost of >$10 billion.

Methods
This multicenter, randomized clinical trial in 16 emergency departments ran between June 2007 and November 2008. Patients were randomly allocated to CCTA (n = 361) or MPI (n = 338) as the index noninvasive test. The primary outcome was time to diagnosis; the secondary outcomes were emergency department costs of care and safety, defined as freedom from major adverse cardiac events in patients with normal index tests, including 6-month follow-up.

Results
The CCTA resulted in a 54% reduction in time to diagnosis compared with MPI (median 2.9 h [25th to 75th percentile: 2.1 to 4.0 h] vs. 6.3 h [25th to 75th percentile: 4.2 to 10.0 h], p < 0.0001). Costs of care were 38% lower compared with standard (median $2,137 [25th to 75th percentile: $1,660 to $3,077] vs. $3,458 [25th to 75th percentile: $2,900 to $4,297], p < 0.0001). The diagnostic strategies had no difference in major adverse cardiac events after normal index testing (0.0% in the CCTA arm vs. 0.4% in the MPI arm, p = 0.29).

Conclusions
In emergency department acute, low-risk chest pain patients, the use of CCTA results in more rapid and cost-efficient safe diagnosis than rest-stress MPI. Further studies comparing CCTA to other diagnostic strategies are needed to optimize evaluation of specific patient subsets. (Coronary Computed Tomographic Angiography for Systematic Triage of Acute Chest Pain Patients to Treatment [CT-STAT]. NC1004683325) J Am Coll Cardiol 2011;58:1414-22 © 2011 by the American College of Cardiology Foundation
## Table 3: Study Outcomes: Efficiency, Cost, and Safety

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>CCTA Group (n = 361)</th>
<th>MPI Group (n = 338)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to diagnosis, h</td>
<td>2.9 (2.1-4.0)</td>
<td>6.2 (4.2-19.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total ED costs, $</td>
<td>2.137 (1,660-3,077)</td>
<td>3,458 (2,900-4,297)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>MACE in patients with normal index test</td>
<td>2/268 (0.8%)</td>
<td>1/266 (0.4%)</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Values are median (25th to 75th percentiles) or n/N (%).

MACE = major adverse cardiac events; other abbreviations as in Tables 1 and 2.
CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): an open-label, parallel-group, multicentre trial

The SCOT-HEART investigators*

Summary
Background The benefit of CT coronary angiography (CTCA) in patients presenting with stable chest pain has not been systematically studied. We aimed to assess the effect of CTCA on the diagnosis, management, and outcome of patients referred to the cardiology clinic with suspected angina due to coronary heart disease.

Methods In this prospective open-label, parallel-group, multicentre trial, we recruited patients aged 18–75 years referred for the assessment of suspected angina due to coronary heart disease from 12 cardiology chest pain clinics across Scotland. We randomly assigned (1:1) participants to standard care plus CTCA or standard care alone. Randomisation was done with a web-based service to ensure allocation concealment. The primary endpoint was certainty of the diagnosis of angina secondary to coronary heart disease at 6 weeks. All analyses were intention to treat, and patients were analysed in the group they were allocated to, irrespective of compliance with scanning. This study is registered with ClinicalTrials.gov; number NCT01149590.

Findings Between Nov 18, 2010, and Sept 24, 2014, we randomly assigned 4146 (42%) of 9849 patients who had been referred for assessment of suspected angina due to coronary heart disease. 47% of participants had a baseline clinic diagnosis of coronary heart disease and 36% had angina due to coronary heart disease. At 6 weeks, CTCA reclassified the diagnosis of coronary heart disease in 558 (27%) patients and the diagnosis of angina due to coronary heart disease in 481 (23%) patients (standard care 22 [1%] and 23 [1%]; p=0.0001). Although both the certainty (relative risk [RR] 2.56, 95% CI 2.33–2.79; p=0.0001) and frequency of coronary heart disease increased (1.09, 1.02–1.17; p=0.0472), the certainty increased (1.79, 1.62–1.96; p=0.0001) and frequency of coronary heart disease decreased (0.93, 0.85–1.02; p=0.0001) for the diagnosis of angina due to coronary heart disease. This changed planned investigations (35% vs 1%; p=0.0001) and treatments (23% vs 5%; p=0.0001) but did not affect 6-week symptom severity or subsequent admissions to hospital for chest pain. After 1–7 years, CTCA was associated with a 38% reduction in fatal and non-fatal myocardial infarction (26 vs 42, HR 0.62, 95% CI 0.38–1.01; p=0.0527), but this was not significant.

Interpretation In patients with suspected angina due to coronary heart disease, CTCA clarifies the diagnosis, enables targeting of interventions, and might reduce the future risk of myocardial infarction.

Funding The Chief Scientist Office of the Scottish Government Health and Social Care Directorates funded the trial with supplementary awards from Edinburgh and Lothian’s Health Foundation Trust and the Heart Diseases Research Fund.

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SCOT-HEART Trial

- Patients recruited in the age range of 18-75.
- 12 Chest pain clinics across Scotland
- Randomized to standard care vs. CCTA
- Primary endpoint: certainty of the diagnosis of angina secondary to coronary heart disease at 6 weeks
SCOT-HEART Trial

<table>
<thead>
<tr>
<th></th>
<th>Standard care and CTCA</th>
<th>Standard care</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cancellation</td>
<td>New</td>
</tr>
<tr>
<td>Investigations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress imaging</td>
<td>121</td>
<td>5</td>
</tr>
<tr>
<td>Invasive coronary angiography</td>
<td>29</td>
<td>94</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>99</td>
</tr>
<tr>
<td>Medical treatments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preventive treatment</td>
<td>77</td>
<td>293</td>
</tr>
<tr>
<td>Antianginal treatment</td>
<td>112</td>
<td>82</td>
</tr>
<tr>
<td>Total</td>
<td>189</td>
<td>375</td>
</tr>
</tbody>
</table>

CTCA = CT coronary angiography.

Table 4: Changes in investigations and treatments at 6 weeks

A CHD death and myocardial infarction

Proportion of patients with an event (%)

Number at risk
CTA Standard care
2073 1571 853 323
1550 837 316

HR 0.62 (95% CI 0.38-1.01); p=0.0527
Assessment of Ischemia

• Cardiac CTA has high sensitivity and a proven ability to exclude coronary artery disease.

• However, the lower specificity and the limited positive predictive value often leads to overestimation of stenosis and to additional unnecessary testing.

• Anatomic assessment of coronary stenosis alone does not accurately predict the functional significance of coronary lesions.

• Three techniques have been studies to add functional testing to the anatomic test of CTA:
  • Transluminal Attenuation Gradients (TAG)
  • Computer Tomorgraphy Perfusion (CTP)
  • Fractional Flow Reserve from CT (FFR CT/CT FFR)
Computational fluid dynamic (CFD) modeling is applied to the coronary CTA dataset without the need for induction of hyperemia or alterations to the scan protocol.

Wikipedia definition of CFD: a branch of fluid mechanics that uses numerical analysis and algorithms to solve and analyze problems that involve fluid flows.

No additional contrast or radiation exposure is required with FFR-CT, and it can be performed from studies using 64 detector row scanners.

Three randomized control trials have been performed to evaluate FFR-CT:

• DISCOVER-FLOW
• DeFACTO
• HeartFlowNXT

Cardiovasc Diagn Ther 2017;7(5):463-474
Diagnosis of Ischemia-Causing Coronary Stenoses by Noninvasive Fractional Flow Reserve Computed From Coronary Computed Tomographic Angiograms

Results From the Prospective Multicenter DISCOVER-FLOW (Diagnosis of Ischemia-Causing Stenoses Obtained Via Noninvasive Fractional Flow Reserve) Study

Bon-Kwon Koo, MD, PhD,* Andrejs Erglis, MD, PhD;† Joon-Hyung Doh, MD, PhD;‡ David V. Daniels, MD,§ Sanda Jegere, MD,∥ Hyo-Soo Kim, MD, PhD,* Allison Dunning, MD,¶ Tony DeFrance, MD,# Alexandra Lansky, MD,** Jonathan Leipsic, BSc, MD,†† James K. Min, MD‡‡

Seoul and Goyang, South Korea; Riga, Latvia; Palo Alto, San Francisco, and Los Angeles, California; New York, New York; New Haven, Connecticut; and Vancouver, British Columbia, Canada
• DISCOVER-FLOW (Diagnosis of Ischemia-Causing Stenoses Obtained Via Noninvasive Fractional Flow Reserve) study
• Assessed the accuracy of noninvasive FFR-CT versus invasive FFR in 103 patients with known or suspected coronary artery disease.
• Found FFR-CT to be more predictive of reduced invasive FFR (FFR ≤0.80) on a per-vessel basis than stenosis on CTA.
**Figure 3**

ROC Demonstrating the AUC for $\text{FFR}_{CT}$ and CCTA Stenosis for the Discrimination of Lesions That Cause Ischemia on a Per-Vessel and Per-Patient Level

Areas under the receiver-operator characteristic curve (AUC) on a per-patient (right) and per-vessel (left) level for ischemia by fractional flow reserve $\leq 0.80$ by coronary computed tomography angiography (CCTA) stenosis $\geq 50\%$ or computation of fractional flow reserve from coronary computed tomographic angiography data ($\text{FFR}_{CT}$) $\leq 0.80$. ROC = receiver-operator characteristic.
DeFACTO Trial

- Prospective DeFACTO (Determination of Fractional Flow Reserve by Anatomic Computed Tomographic Angiography) trial.
- FFR-CT was compared with FFR in 252 patients.
- FFR-CT showed higher accuracy on a per-patient basis than CTA in predicting invasive FFR (area under the curve [AUC] = 0.81 and 0.68, respectively).
**Figure 1** Anatomically Obstructive Stenosis With No Functional Ischemia

(A) Coronary computed tomography angiography demonstrating obstructive (>=50%) stenosis (white arrow) in the obtuse marginal (OM) branch of the left circumflex artery. Proximal and distal to the lesion, there are multiple areas of diffuse calcified plaque of intermediate stenosis severity (40% to 69%). (B) Invasive coronary angiography confirms the obstructive OM stenosis (red arrow). (C) Computation of fractional flow reserve from coronary computed tomographic angiography data (FFR<sub>CT</sub>) demonstrates no ischemia in the OM, with a computed value of 0.85. (D) Fractional flow reserve (FFR) of 0.84 at the time of invasive coronary angiography similarly demonstrates no ischemia in the OM.
Diagnostic Performance of Noninvasive Fractional Flow Reserve Derived From Coronary Computed Tomography Angiography in Suspected Coronary Artery Disease

The NXT Trial (Analysis of Coronary Blood Flow Using CT Angiography: Next Steps)

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on behalf of the NXT Trial Study Group

Aarhus, Denmark; Vancouver, British Columbia, Canada; Victoria, Australia; Okayama, Japan; Boston, Massachusetts; Aalst, Belgium; Cleveland, Ohio; Erlangen and Essen, Germany; Riga, Latvia; and Seoul, South Korea
NXT Trial

- NXT (Analysis of coronary blood flow using CT angiography: NeXt sTeps) trial.
- Compared FFR-CT to FFR in 484 vessels from 251 subjects.
- FFR-CT showing improved diagnostic accuracy over CTA alone on a per-patient (AUC = 0.90 vs. 0.81) and a per-vessel (AUC = 0.93 vs. 0.79) basis.
The Updated NICE Guidelines: Cardiac CT as the First-Line Test for Coronary Artery Disease

Alastair J. Moss¹ · Michelle C. Williams¹ · David E. Newby¹ · Edward D. Nicol²

Assessing and diagnosing suspected stable angina

Diagnostic investigations

Include the typicality of anginal pain features (see assess the typicality of chest pain) in all requests for diagnostic investigations and in the person’s notes.

Use clinical judgement and take into account people’s preferences and comorbidities when considering diagnostic testing.

First-line: 64-slice CT coronary angiography

Offer 64-slice (or above) CT coronary angiography if:
- clinical assessment indicates typical or atypical angina, or
- clinical assessment indicates non-anginal chest pain but 12-lead resting ECG has been done and indicates STT changes or Q waves.

Second-line: non-Invasive functional testing
Questions?