Getting familiar with CT coronary angiography

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Learning objectives

• 1. Understand the basics of how CT coronary angiography images are acquired including methods to optimize image quality and reduce radiation dose

• 2. Knowledge of how to assess CT coronary angiography images and communicate results
Advances in CT imaging

“A further promising field may be the detection of the coronary arteries.”

Godfrey Hounsfield, Nobel Lecture, 1979
Advances in CT imaging

1990 → 1996 → 2002 → 2003 → 2005

1 slice

1 slice
Overlapping algorithm

4 slice

16 slice

64 slice

HOW TO DO
CT CORONARY ANGIOGRAPHY
Patient preparation

- Relaxed comfortable environment
- Measure pulse, blood pressure, height, weight
- Intravenous catheter - right arm
Pre medication
Pre medication

- Beta blocker
  - Oral metoprolol
  - Intravenous metoprolol
  - Oral ivabradine
  - (Calcium channel blockers)

- Glyceryl trinitrate (GTN)
  - Sublingual tablet or spray
Scan type

A  Step and shoot

B  Helical

Volume
Scout images
Patient tailored imaging
Patient tailored imaging - Z-axis coverage
Patient tailored imaging - Electrocardiogram gating

A. Full R-R exposure

B. Full R-R exposure

C. Trigger delay
   PW
   30%  90%

D. PW
   75%
Patient tailored imaging – Tube current and tube voltage

• Based on body mass index
• Based on scout image
  – Automatically by scanner
  – Manually by assessing circumference or diameter
Iodinated contrast

Ionic monomer
3 iodine atoms : 2 particles, Ratio : 1.5

Non-ionic monomer
3 iodine atoms : 1 particle, Ratio : 3.0

Ionic dimer
6 iodine atoms : 2 particles, Ratio : 3.0

Non-ionic dimer
6 iodine atoms : 1 particle, Ratio : 6.0
Test bolus

Low dose contrast scan

Use to calculate timing for real scan
Bolus tracking
Image Reconstruction

• Reconstruction algorithm
  – Filtered back projection
  – Iterative reconstruction
  – Model based reconstruction

• Reconstruction kernel
  – Medium soft
  – Sharper for stents or valves
Radiation

• Radiation dose is a major health care concern

• Computed tomography is widely used
  – 70 million CT/year in US
  – 4 million CT/year in UK

• Cardiac imaging is responsible for up to 30% of radiation exposure due to diagnostic imaging
Radiation dose reduction in CTCA

- Tube current optimisation
- Heart rate reduction
- Prospective ECG gating
- Tube voltage optimisation
- Scan range optimisation
- Patient tailored imaging
- Tube current modulation
- Iterative reconstruction
Low dose CT coronary angiography

Average for all heart rates and all BMI 2.5 mSv

Submillisievert scanning for BMI <25 and HR <65

Average dose for all heart rates and all BMI <25 and HR <65 is 2.5 mSv.
HOW TO ASSESS AND REPORT CT CORONARY ANGIOGRAPHY
Don’t forget everything else ...
Calcium score
CT stenosis assessment
CT stenosis assessment

<10%  10-50%  50-70%  >70%

Williams et al, Open Heart 2015
The problem with calcium

Williams MC et al, Heart, 2011
The problem with calcium

- Beam hardening and photon starvation
- Partial volume averaging, “blooming”
Beware of artifacts
Beware of artifacts
Vulnerable plaque

- Inflammation
- Thin Fibrous Cap
- Micro-Calcification
- Large Necrotic Core
- Positive Remodeling
- Low Attenuation Plaque

Motoyama JACC 2009, Maurovitch-Horvat JACC Imaging 2010
Plaque quantification
CAD-RADS

Cury R C, JCCT 2016
<table>
<thead>
<tr>
<th>CAD-RADS</th>
<th>Degree of maximal coronary stenosis</th>
<th>Interpretation</th>
<th>Further Cardiac Investigation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0% (No plaque or stenosis)</td>
<td>Documented absence of CAD</td>
<td>None</td>
<td>- Reassurance. Consider non-atherosclerotic causes of chest pain</td>
</tr>
<tr>
<td>1</td>
<td>1–24% - Minimal stenosis or plaque with no stenosis(^a)</td>
<td>Minimal non-obstructive CAD</td>
<td>None</td>
<td>- Consider non-atherosclerotic causes of chest pain</td>
</tr>
<tr>
<td>2</td>
<td>25–49% Mild stenosis</td>
<td>Mild non-obstructive CAD</td>
<td>None</td>
<td>- Consider preventive therapy and risk factor modification, particularly for patients with non-obstructive plaque in multiple segments.</td>
</tr>
<tr>
<td>3</td>
<td>50–69% stenosis</td>
<td>Moderate stenosis</td>
<td>Consider functional assessment</td>
<td>- Consider symptom-guided anti-ischemic and preventive pharmacotherapy as well as risk factor modification per guideline-directed care (^b)</td>
</tr>
<tr>
<td>4</td>
<td>A - 70–99% stenosis or B - Left main &gt;50% or 3-vessel obstructive (≥70%) disease</td>
<td>Severe stenosis</td>
<td>A: Consider ICA(^a) or functional assessment</td>
<td>- Other treatments should be considered per guideline-directed care (^c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B: ICA is recommended</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>100% (total occlusion)</td>
<td>Total coronary occlusion</td>
<td>Consider ICA and/or viability assessment</td>
<td>- Consider symptom-guided anti-ischemic and preventive pharmacotherapy as well as risk factors modification per guideline-directed care (^d)</td>
</tr>
<tr>
<td>N</td>
<td>Non-diagnostic study</td>
<td>Obstructive CAD cannot be excluded</td>
<td>Additional or alternative evaluation may be needed</td>
<td>- Other treatments (including options of revascularization) should be considered per guideline-directed care (^e)</td>
</tr>
</tbody>
</table>

\(^a\) CAD-RADS 0 and 1 correspond to the absence of CAD.

\(^b\) Includes considerations for patients with non-obstructive plaque in multiple segments.

\(^c\) For A: Consider ICA or functional assessment.

\(^d\) For B: ICA is recommended.

\(^e\) For C: Additional or alternative evaluation may be needed.
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<th>Degree of maximal coronary stenosis</th>
<th>Interpretation</th>
<th>Management</th>
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| CAD-RADS 0 0%                    | ACS\(^b\) highly unlikely | - No further evaluation of ACS is required.  
- Consider other etiologies. |
| CAD-RADS 1 1–24\(^b\)            | ACS highly unlikely   | - Consider evaluation of non-ACS etiology, if normal troponin and no ECG changes.  
- Consider referral for outpatient follow-up for preventive therapy and risk factor modification. |
| CAD-RADS 2 25–49\(^c\)           | ACS unlikely         | - Consider evaluation of non-ACS etiology, if normal troponin and no ECG changes.  
- Consider referral for outpatient follow-up for preventive therapy and risk factor modification.  
- If clinical suspicion of ACS is high or if high-risk plaque features are noted, consider hospital admission with cardiology consultation.  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modification. Other treatments should be considered if presence of hemodynamically significant lesion.  
- Consider hospital admission with cardiology consultation. Further evaluation with ICA and revascularization as appropriate. |
| CAD-RADS 3 50–69%                | ACS possible         | - Consider hospital admission with cardiology consultation, functional testing and/or ICA\(^d\) for evaluation and management.  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modification. Other treatments should be considered if presence of hemodynamically significant lesion.  
- Consider hospital admission with cardiology consultation. Further evaluation with ICA and revascularization as appropriate.  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modification.  
- Consider expedited ICA on a timely basis and revascularization if appropriate if acute occlusion\(^e\)  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modifications. |
| CAD-RADS 4 A 70–99% or B Left main >50% or 3-vessel obstructive disease | ACS likely           | - Consider hospital admission with cardiology consultation. Further evaluation with ICA and revascularization as appropriate.  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modification.  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modifications. |
| CAD-RADS 5 100% (Total occlusion)| ACS very likely       | - Consider expedited ICA on a timely basis and revascularization if appropriate if acute occlusion\(^e\)  
- Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modifications. |
| CAD-RADS N Non-diagnostic study  | ACS cannot be excluded| Additional or alternative evaluation for ACS is needed. |

\(^a\) ACS: acute coronary syndrome
\(^b\) Represents the extent of stenosis on the visual analog scale.
\(^c\) Represents the extent of stenosis on the quantitative coronary angiography.
\(^d\) ICA: invasive coronary angiography
\(^e\) Acute occlusion: a thrombus or other occluding material within an artery that causes an abrupt reduction in blood flow.
CAD-RADS – modifiers

- N – non-diagnostic
- S – stent
- G – graft
- V - vulnerability
CAD-RADS 0
CAD-RADS 3
CAD-RADS 4B / V

BMI 23
0.86 mSv (k=0.014).
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Radiation dose reduction in CTCA

Williams MC, Clinical Radiology 2013