CCTA:
A Noninvasive Assessment of CAD

In this article, Dr. Heilbron and Dr. Forster look at the noninvasive assessment of coronary artery disease (CAD), by means of coronary computed tomography angiography (CCTA).

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What is CCTA?

CCTA utilizing 64-multidetector (MDCT) technology is a novel tool, which allows for the noninvasive detection and quantitation of CAD at a significantly higher level of safety and at a lower cost than catheter coronary angiography. In addition, CCTA provides information regarding cardiac structure and function.

How is CCTA performed?

CCTA involves intravenous (IV) injection of an iodinated contrast agent, typically 90 mL, followed immediately with a saline flush. This volume is similar to that required for diagnostic coronary angiography. Imaging is performed during a single breath hold, with a study acquisition time of approximately 10 seconds for 64-MDCT.

Because image quality improves with lower heart rates, ß-blockers are often utilized for rates above 65 bpm. Sublingual nitroglycerin is given immediately prior to the exam for its coronary vasodilatory effect.

A number of hospitals in Canada have recently started performing CCTA with 64-MDCT scanners. Canada Diagnostic Centres in Vancouver is the only private facility currently performing CCTA, utilizing 64-MDCT technology. More than 200 patients have had CCTA performed there so far.

Adam's Atypical Chest Pain

Adam, 54, was investigated with an exercise treadmill test owing to atypical chest pain. He has no prior cardiac history. His cardiac risk factors include borderline dyslipidemia and a family history of sudden death (in his father at age 55). He was started on 81 mg of acetylsalicylic acid and a statin, but developed muscle aching.

He completed 13 minutes of the Bruce protocol and the test was terminated owing to fatigue and achievement of his target heart rate. His resting BP was 168/92 mmHg and peak BP was 224/94 mmHg. The test was interpreted as being equivocal for ischemia owing to 1 mm of upsloping ST depression in the inferolateral leads at peak exercise. A subsequent myocardial perfusion imaging test reported a small area of inferior wall ischemia, with a left ventricular ejection fraction (LVEF) of 58%.

Coronary computed tomography angiography (CCTA) revealed diffuse coronary atherosclerosis, with no stenoses exceeding 50% (Figure 1). Adam's LVEF was 64% with no wall motion abnormalities (Figure 2). He was incidentally noted to have a hiatus hernia.

Adam was advised to enroll in an exercise program, was referred to a dietitian and was started on an angiotensin-converting enzyme inhibitor and proton pump inhibitor. The statin dose was halved and niacin was added. His atypical chest pain resolved.

Table 1
Indications and contradindications to CCTA

Indications	Contradindications
Atypical chest pain	Allergy to IV contrast agents
Equivocal or inconclusive noninvasive cardiac testing	Chronic renal disease of sufficient severity to prohibit use of IV contrast agents (GFR < 30)
Interval assessment of documented CAD	Irregular or rapid heart rates (*e.g.,* atrial fribrillation or frequent ectopy)
Assessment of coronary artery stents and bypass grafts	Extensive coronary artery calcification (*e.g.,* Agatston score of > 1500 units)
Unexplained left ventricular systolic dysfunction	Inability to hold breath or remain motionless for 10 seconds
Preoperative assessment of valvular heart disease	Patients with a high likelihood of requiring percutaneous coronary intervention
Individuals with multiple strong risk factors but no previous documented CAD	

IV: Intravenous GFR: Glomerular filtration rate CAD: Coronary artery disease

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Dr. Forster is an Associate Professor and Vice Chairman (Research) of Radiology, University of British Columbia and Medical Director of Canada Diagnostic Centres in Vancouver, British Columbia, where he co-interprets CCTA and interprets other CT/MRI imaging studies.

What are the risks?

The use of IV contrast agents is associated with a small risk of anaphylactoid reaction and nephropathy.

Discomfort or bruising at the vein injection site (usually the forearm or hand) may occur.

CCTA requires a radiation dose in the range of 8 milliSieverts (mSv) to 15 mSv. Other frames of reference include coronary artery calcification scoring (1.3 mSv), coronary artery angiography (6 mSv), routine abdominopelvic CT imaging (10 mSv), myocardial perfusion (MIBI) imaging (8 mSv for technetium-99 and 18 mSv for thallium-201) and average annual background radiation (2.0 mSv in Vancouver).

CCTA indications and contraindications

The indications and contraindications to using CCTA to evaluate the presence and severity of coronary atherosclerosis are shown in Table 1.

What do the studies show?

Multiple studies have evaluated the correlation between CCTA and catheter coronary angiography. The sensitivity and specificity of CCTA for the detection and quantitation of coronary atherosclerosis in selected patients is > 95%. The temporal resolution of CCTA is not quite as good as invasive coronary angiography (67 msec to 200 msec using MDCT vs. 15 msec to 30 msec, respectively), but is sufficient to make a clinical diagnosis and plan appropriate therapy in the majority of patients.

Studies have evaluated the utility of CCTA in patients with coronary artery stents. In general, this technology provides adequate visualization of large proximal stents, but inadequate assessment of smaller distal vessels or side-branches (artery diameter < 2.5 cm) (Figure 3).

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Figure 1. CCTA curved multiplanar reformat of the left anterior descending coronary artery, which demonstrates diffuse atherosclerosis, but no significant stenoses.

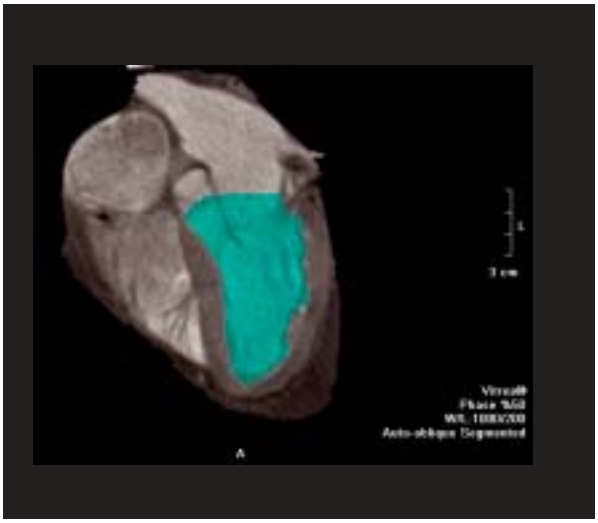

Figure 2. CCTA functional analysis, which revealed a LVEF of 64% and no wall motion abnormalities.

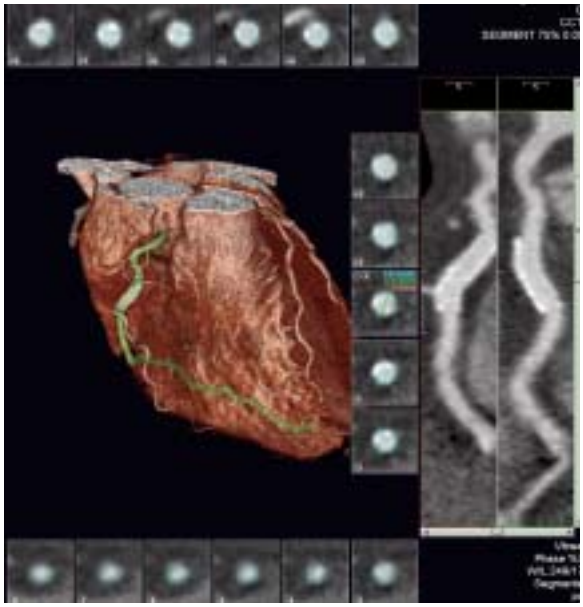

Figure 3. Example of a widely patent mid-right coronary artery stent.

Figure 4. Example of a patient with two vein grafts (to the second diagonal branch of the left anterior descending (LAD) artery and the first obtuse marginal branch of the circumflex) and a left internal mammary graft to the LAD.

CCTA provides an accurate evaluation of the presence and severity of coronary atherosclerosis, at a significantly higher level of safety and at a lower cost than catheter coronary angiography.

CCTA studies (and our own experience) in patients with prior coronary artery bypass grafting reveal good visualization of the bypass grafts (Figure 4), but poor visualization of the native vessels, which are often heavily calcified and diffusely diseased.

Ongoing studies are evaluating the utility of CCTA in the ED setting for the evaluation of patients with atypical presentations for:

- acute coronary syndromes,
- pulmonary embolism, or
- aortic dissection ("triple rule-out").

What is the role of CACS?

Coronary artery calcium (CAC) scoring has is routinely done at the time of CCTA. In individuals with an intermediate Framingham risk score, an elevated CAC score (> 400 Agatston units) adds incremental prognostic power. A very low Agatston score (< 10 units) in individuals at low-risk of having coronary atherosclerosis may be used as justification for not proceeding with CCTA (in order to avoid the contrast agent and radiation exposure).

Take-home message

- CCTA is an exciting new tool for the noninvasive assessment of CAD. In selected patients it provides an accurate evaluation of the presence and severity of coronary atherosclerosis, at a significantly higher level of safety and at a lower cost than catheter coronary angiography
- Appropriate patient selection is crucial to the optimal use of this technology

A limitation to this approach is that a small percentage of individuals may have significant stenoses related to non-calcified atheroma, despite a low CAC score. Conversely, a very high score (*i.e.*, > 1500 units) is usually associated with extensive significant CAD and proceeding with CCTA in these patients does not usually change clinical management, as these patients require aggressive secondary prevention measures and consideration for invasive coronary angiography.

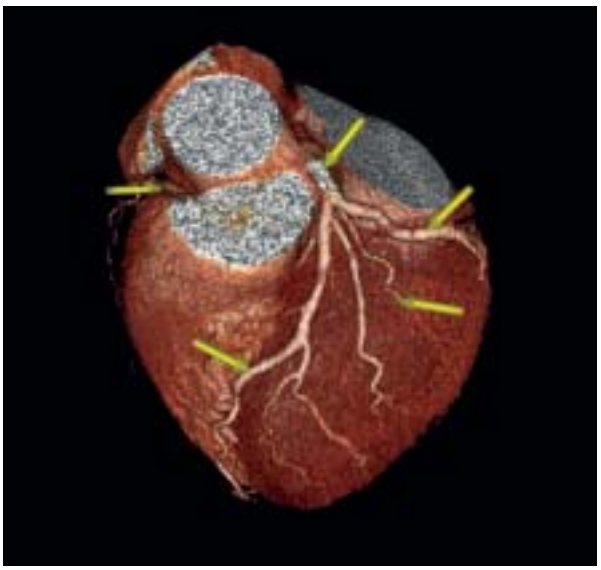

Figure 5. Normal coronary artery anatomy demonstrated in a 3-D volume-rendered CCTA reconstruction.

Recommended reading

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