Multidetector-row computed tomography to detect coronary artery disease: the importance of heart rate

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Atherosclerosis resulting in coronary heart disease is a potentially preventable cause of death. Early non-invasive detection of unstable plaques in the coronary arteries may identify patients at risk for myocardial infarction, who can be aggressively treated to prevent cardiac events. The recent development of high-resolution 64-row CT scanners allows non-invasive high-quality visualization of ≥90% of the segments of coronary arteries within a few seconds. In addition, calcified, fibrous, and lipid-laden plaques can be differentiated. Strategies to optimize multidetector-row computed tomography (MDCT) imaging include careful choice of the reconstruction time point in the cardiac cycle, optimum contrast enhancement, and control of heart rate. When heart rate is >65 b.p.m., motion artifacts may compromise image quality. Thus, use of beta-blockers is recommended to control heart rate. Heart rate may also be slower and more consistent when a non-ionic, dimeric, iso-osmolar contrast medium (CM) rather than a hyper-osmolar ionic CM is used for image enhancement. When properly performed, advantages of MDCT for assessing coronary arteries include speed, information on the composition of atherosclerotic plaques, and no need for arterial access or hospitalization. Moreover, unlike angiography, MDCT can assess multiple potential causes of chest pain (heart attack, pulmonary embolism, aortic dissection) simultaneously.

Introduction

Atherosclerosis resulting in coronary heart disease (CHD) is the single leading cause of death in the United States and accounts for about half of all deaths in Europe. Atherosclerosis is a heterogeneous disease that can manifest as stable fibrous lesions, unstable lipid-rich lesions, or mixtures of both in the vessel wall. Plaque composition is an essential predictor of plaque rupture and acute clinical complications. Atheromas with areas of extracellular lipid and necrotic cores under a fibrous cap are most likely to cause death (Figure 1). Because >50% of patients die from CHD within hours of symptom onset, early detection of unstable plaques followed by aggressive risk-reduction therapy to prevent events appears to be the ideal therapeutic approach.

During the past few years, rapid progress has been made in non-invasive imaging of coronary artery disease (CAD) that provides information on plaque composition. Currently available imaging techniques will be reviewed. One of the most promising techniques, multidetector-row computed tomography (MDCT) of the coronary arteries, will be described in detail, including strategies for improving image quality by managing heart rate.

Current imaging techniques

Invasive techniques

Angiography

Currently, the reference standard for diagnosing CAD is selective cardiac catheterization with angiography using iodinated contrast media (CM), which provides high spatial resolution of the vessel lumen. However, this
procedure requires arterial access. Although arterial penetration allows percutaneous intervention to be performed immediately if necessary, it is also associated with a small risk of adverse events including bleeding, haematoma, infection, stroke, coronary artery dissection, and death. Moreover, angiography effectively demonstrates thrombotic occlusion or vessel stenosis but does not elucidate the size or composition of atherosclerotic plaques. If a plaque is not obstructive, as many plaques prone to rupture are not, it may not be detected. Indeed, it is estimated that nearly two-thirds of all myocardial infarction (MI) originate with atherosclerotic lesions that do not obstruct blood flow prior to rupture. Thus, it is reasonable that 20–40% of patients considered at risk for cardiovascular disease may have normal angiograms.

Intravascular ultrasound
Intravascular ultrasound (IVUS) is a catheter-based technique that not only identifies areas of stenosis but also determines plaque composition (i.e. calcification, thrombus, the dimensions of the fibrous cap, and lipid content). A recent study showed that IVUS detected significant lesions in patients with minimal angiographic findings, and that these lesions predicted the likelihood of cardiac events. However, the adverse events associated with arterial access for angiography are also a concern with this technique, which is also time consuming and requires technical skills. In addition, the catheter cannot penetrate beyond areas of severe stenosis.

Non-invasive imaging techniques
Theoretical advantages of non-invasive imaging of the cardiovascular system include increased safety because no arterial access is needed, rapid acquisition of data, detection of non-stenotic coronary lesions, and lower cost (in part because less physician and hospital time are required). With improvements in technology, non-invasive methods may eventually be used to routinely assess asymptomatic or minimally symptomatic atherosclerosis and monitor disease progression, stabilization, or regression.

Imaging of the coronary artery system presents special challenges because of the small diameter of the coronary vessels and the complex three-dimensional (3D) shape and rapid movement of these vessels during the cardiac cycle. Achieving adequate image quality has been a major goal of research and development in this field.

Magnetic resonance imaging
Magnetic resonance imaging (MRI) provides excellent soft tissue resolution and is able to image plaque in the peripheral vasculature, aorta, and carotid arteries. When human coronary arteries in autopsy samples were examined, MRI identified fatty, fibrous, and calcified plaque components. However, difficulties have been encountered in imaging coronary arteries in vivo because of a combination of cardiac and respiratory motion artifacts, the non-linear movement, small size, and location of the arteries. Although research is ongoing, visualization of the lumen of a coronary artery can be difficult because of limitations in the spatial and temporal resolution of MRI (Figure 2).

Computed tomography
One of the most promising non-invasive procedures is computed tomographic (CT) angiography. Unlike traditional X-ray imaging that produces a 2D snapshot, CT angiography involves taking thin X-ray scans of <1 mm thickness from multiple directions. The multiple scans are combined using special computer algorithms to form an image of a 'slice' of the body. Adjacent slices are then stacked by computer to produce a 3D image. CT is successfully used for 3D imaging of the chest, abdomen, kidney, liver, brain, and heart.

To eliminate motion artifacts from cardiac CT scans, the procedure must be synchronized with the heart.
cycle. Two primary techniques are used to synchronize CT scanning with the patient’s electrocardiogram (ECG): prospective triggering and retrospective gating. Prospective triggering directs the CT scanner to take X-ray scans only at a certain phase of the cardiac cycle. It is usually the diastolic phase because this is when the heart has the least motion. Prospective triggering has the advantage of minimizing X-ray exposure because only the minimum data needed are acquired. However, it depends on a regular heart rate because an arrhythmic heart may confuse the ECG trigger. Also, because the motion patterns of the major cardiac arteries differ during the cardiac cycle, prospective triggering may produce images optimized for only some of the arteries.

In retrospective gating, the heart is scanned continuously for several cycles, but only scans from a particular phase of the ECG are used for image reconstruction. This improves visualization of the heart but exposes the patient to a higher dose of X-ray radiation. Retrospective gating is currently used by all CT scanner manufacturers for CT angiography of the heart.

**Electron beam computed tomography.** Electron beam CT (EBCT) scanners were the first generation of CT scanners used for cardiology studies. The EBCT imaging process involves production of a continuous 30° X-ray fan beam that passes through the patient and is collected by the stationary row of detectors. Data acquisition is prospectively triggered on the basis of ECG data, and image slices are acquired sequentially as the patient table is slowly advanced to produce images optimized for only some of the arteries.

Advantages of EBCT are the low radiation exposure given to the patient and the single image acquisition time of only 50–100 ms, which limits motion artifacts. The disadvantages of EBCT are its somewhat low signal-to-noise ratio, its relatively long total scan time, and images limited to one point of the cardiac cycle.

Images produced by EBCT for clinical use are generally obtained without intravascular contrast and are used to quantitate total calcium in the coronary tree. The relevance of this measurement is controversial, as plaques likely to rupture may not be calcified. According to a consensus report from the American College of Cardiology/American Heart Association, a negative EBCT makes the presence of atherosclerotic plaque, including unstable plaque, unlikely. However, a positive EBCT confirms the presence of coronary atherosclerosis and is consistent with the possibility of occlusive heart disease, which may lead to coronary events.

**Multidetector-row computed tomography.** MDCT gathers multiple images simultaneously and continuously, thus acquiring a greater amount of diagnostic information per unit time. In this method a gantry—which houses the X-ray source, collimators to focus the beam, and detectors—is rotated around the patient. The data are acquired during a continuous scan and retrospectively ECG-gated. Typical scan time for a single acquisition is currently ~10 s.

In the pre-spiral CT era, one 360° rotation of the gantry produced data for one image slice of the patient. To capture the next slice, the patient table was usually moved a distance equal to the slice thickness and came to a complete stop. The gantry then made another 360° rotation in the opposite direction, the table was moved again, and so on. The computed slices were ‘stacked’ in a computer and a limited 3D image could then be constructed. Substantial cardiac motion artifacts were introduced because the acquisition time for each image was 1–2 s and the utility of CT in cardiac imaging was limited.

The introduction of slip-ring technology in the late 1980s allowed the gantry to rotate continuously in one direction. This allowed scanning by rotating the gantry for multiple revolutions without stopping while the patient table slowly advanced to produce a so-called spiral or helical CT (Figure 3). Total scan time was significantly reduced.

In the late 1990s, spiral CT scanners were further improved with the addition of multiple-detector rows and increased rotation speed of the gantry. MDCT allows some overlap between the rotations, which significantly improves spatial resolution. When compared with single-detector-row CT, the 16-MDCT acquires 16 slices per rotation instead of one. Although 16-, 32-, and 40-MDCT systems are available, the state-of-the-art is currently a 64-MDCT, which acquires 64 slices in a single scan rotation, scanning the heart within as little as 5 s (i.e. five heartbeats). Improvements in CT with respect to scanning speed and resolution over the past few decades are summarized in Table 1.

**Table 1.** The evolution of CT

<table>
<thead>
<tr>
<th>Year</th>
<th>Scan speed (s)</th>
<th>Scan thickness (mm)</th>
<th>Interscan spacing (mm)</th>
<th>Total number of slices</th>
</tr>
</thead>
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<tr>
<td>1980</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>25 – 30</td>
</tr>
<tr>
<td>1985</td>
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<td>30 – 45</td>
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<td>1</td>
<td>3.5</td>
<td>3.5</td>
<td>100</td>
</tr>
<tr>
<td>1995</td>
<td>0.75</td>
<td>3</td>
<td>2.3</td>
<td>100</td>
</tr>
<tr>
<td>1999</td>
<td>0.55</td>
<td>1.3</td>
<td>1.3</td>
<td>220</td>
</tr>
<tr>
<td>2003</td>
<td>0.4</td>
<td>0.5–0.75</td>
<td>0.5–0.75</td>
<td>400–1200</td>
</tr>
<tr>
<td>2004</td>
<td>0.33</td>
<td>0.5–0.6</td>
<td>0.5–0.75</td>
<td>600–4000</td>
</tr>
</tbody>
</table>

*Scanner rotation speed.

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![Figure 3](https://academic.oup.com/eurheartjsupp/article-abstract/7/suppl_G/G4/402835/402835)
The increased scan speed of 64-MDCT (temporal resolution) optimizes imaging of the arteries separately from the veins and better defines zones with differential enhancement (such as false lumens in dissections). The higher spatial resolution of 64-MDCT permits more accurate measurement of stenoses in the coronary arteries, provides better detailing of soft tissues, and allows data to be acquired as isotropic voxels and visualized in high-resolution 3D images. Examples of high-resolution MDCT scans of the coronary vessels are shown in Figure 4.

The clinical utility of MDCT

Although MDCT, to examine the coronary arteries, is still undergoing rigorous clinical validation, it is hoped that MDCT will eventually be used instead of angiography for routine assessment of the coronary arteries. The procedure can be performed more quickly than angiography, (the measurement is made within a few heartbeats) and requires less skill to perform than cardiac catheterization. Catheter-related risks, including bleeding at puncture, are also eliminated, and no hospitalization or close monitoring post-study is required. Studies examining the clinical utility of MDCT have focussed on validating the results compared with invasive techniques, and on maximizing the information that can be acquired in a single measurement. Because the introduction of 64-MDCT is recent, only few studies using this method have been published. Thus, the available studies, which are at best with 16-MDCT, may underestimate the usefulness of MDCT.

Validation of MDCT

Comparison with angiography

The diagnostic utility of MDCT in the heart has been established in a number of clinical studies that compared 16-MDCT with conventional coronary angiography. Overall, the results of these studies have been positive. In 30 patients with an angiographically proven absence of significant coronary artery stenoses, it was possible to visualize 93% of the overall length of the coronary arteries without motion artifacts. Moreover, vessel diameters measured by MDCT closely correlated with those obtained by quantitative coronary angiography. In another study of 59 patients with suspected coronary obstructions, 58 had analysable data sets with a sensitivity and specificity for defining luminal obstructive disease of 95 and 86%, respectively. All patients with significant obstructions were correctly diagnosed. Similar results were obtained in a study of 77 patients with suspected CAD. In 57 of these patients, all coronary arteries were evaluable, and stenoses of >50% were correctly identified with accuracy similar to that of angiography (sensitivity: 92%; specificity: 93%). In a subgroup of 36 patients with a heart rate <60 b.p.m., 96% of all coronary arteries were evaluable. According to another study, all but 6.6% of the images obtained with 16-MDCT were of diagnostic image quality, and the correct clinical diagnosis was obtained in 90% of patients.

Because 16-MDCT can be used successfully to diagnose and to devise treatment strategies for patients with CAD, the non-invasiveness of MDCT is seen as a significant clinical advantage. In a prospective study of 22 patients with suspected CAD, only 68% of the patients required percutaneous coronary intervention, so use of MDCT would have prevented an invasive procedure in 32% of patients. Another study demonstrated that MDCT can replace angiography in post-coronary artery bypass patients, because MDCT has high sensitivity and specificity for assessing graft patency. The patency of coronary stents has also been determined with MDCT. When patients have anomalous coronary arteries, MDCT is superior to angiography. In a study of 44 patients with anomalous coronary arteries, MDCT was able to opacify 100% of vessels regardless of anatomy and to visualize abnormal vessels in relation to the great mediastinal vessels. However, selective cannulation was possible in only 11 of the 20 angiograms performed (55%). MDCT can also identify myocardial bridges, which may lead to angina, ischaemia, or infarction.
Comparison with EBCT and IVUS

Like EBCT, MDCT can identify areas of calcification. Detection of calcified plaques by 16-MDCT has been shown to be nearly identical to that of EBCT (98.7% sensitivity and 100% specificity); 64-MDCT with improved spatial and temporal resolution should surely be considered equal to EBCT in detection of calcification.

Like IVUS, MDCT is able to differentiate plaques on the basis of their content of calcified, lipid, or fibrous material. Results of MDCT and IVUS have been compared directly in several studies. A study of 14 patients with cardiovascular disease affecting 46 vessel segments showed that 16-MDCT identified 37 of these segments (80.4%). Unidentified segments were located distally. In analysable segments, the presence of plaque, the symmetry of plaque distribution, plaque calcification, and vessel remodelling could be identified. In a study of 22 patients without significant coronary stenoses, 16-MDCT had a sensitivity of 82% and a specificity of 88% for detection of any plaque compared with IVUS. The overall sensitivity was maximal for calcified plaque (94%), lower for plaques with some calcification (78%), and lowest for plaques without calcification (53%). Detection was most accurate for large plaques in proximal segments. When plaque map software was used to identify soft, intermediate, or calcified plaque in 45 patients with acute coronary syndrome, sensitivities were 92, 87, and 89%, respectively, relative to IVUS.

IVUS is also used to measure plaque area. In 26 patients, the mean luminal area and the mean plaque area detected by MDCT and IVUS were significantly correlated (P < 0.001), although MDCT overestimated plaque area by ~10%. Because the resolution of current 64-MDCT is in the range of 0.3–0.4 mm, it is likely that the plaque composition and volume determined using this instrumentation will be more comparable to IVUS than the 16-MDCT measurements.

MDCT has been used to differentiate the unstable plaques associated with acute MI from the stable plaques associated with stable angina pectoris. Non-calcified plaques are more often found in patients with MI than in patients with stable angina pectoris, and calcified plaques are more often found in patients with stable angina pectoris than in patients with MI (Figure 5). MDCT also can detect thrombus associated with MI.

Maximizing the efficiency of diagnosis

A potential advantage of 64-slice MDCT is that it rapidly provides considerable diagnostic information and may replace the need for additional testing. For example, when MDCT is used to diagnose the source of chest pain, the possibilities of heart attack, pulmonary embolism, aortic aneurysm, and aortic dissection can be assessed simultaneously. In addition, all data derived during an MDCT scan can be combined to construct a moving 3D (i.e. 4D) representation of the cardiac cycle, which provides information traditionally obtained using echocardiography and ventriculography. In a study of 25 patients, 4-MDCT showed excellent agreement with echocardiography in measurements of regional wall movement and left ventricular ejection fraction. Chamber size, wall thickness, stroke volume, and valve motion have also been evaluated using MDCT. Possible uses for 4D cardiac representations include simultaneous assessment of CAD and left ventricular function in patients with unstable angina and identification of areas of ischaemia, infarction, and arrhythmia in patients with heart disease.

Optimizing MDCT results

Strategies to optimize MDCT imaging of the coronary arteries include improved instrumentation to obtain rapid scans with high spatial resolution (Table 1), careful choice of the reconstruction time point in the cardiac cycle, control of heart rate to minimize motion artifacts, and optimum contrast enhancement. The latter two strategies may be managed by the physician directing the examination.

Managing heart rate

Heart rate is an important parameter for achieving optimal imaging in MDCT. In a survey of the problems experienced while imaging 110 patients with a 4-MDCT scanner, the most common problem was blurring of the image by cardiac motion. In general, when the heart rate is <65 b.p.m., the image can be reconstructed from a single heart cycle. When the heart rate is >65 b.p.m., most MDCT image reconstruction algorithms use data from two consecutive heart cycles (Figure 6). However, two absolutely equal heart cycles are necessary to generate an image free of motion artifacts, a condition that is not always found. Another complication is the need for the patients to hold their breath during scanning because this inevitably increases heart rate during the procedure. A slow, regular heart rate is ideal for image quality.

The impact of heart rate on image quality was first established during studies using 4-MDCT. When 94
Heart rate ≤65 b.p.m  
Heart rate >65 b.p.m  
Single-phase  
M=1 segment  
Biphase  
M=2 segments  

**Figure 6** A CT image reconstructed from two segments may have lower resolution due to non-identical positioning. Reprinted with permission from Elsevier.40

patients undergoing 4-MDCT were grouped according to vessel segment visibility, patients with the highest number of analysable segments had the lowest heart rate (mean 60 ± 10.1), and segment visibility was inversely correlated with heart rate ($r = 0.48$, $P < 0.0001$).40 Gerber et al.42 analysed coronary segments from 126 patients with a 4-MDCT scanner and observed motion artefacts in only 13% of coronary segments at heart rates of 51–60 b.p.m. However, artefacts were observed in 71% of coronary segments at heart rates of 61–70 b.p.m.42 Overall sensitivity for stenosis detection with 4-MDCT decreased from 62 to 33% when the heart rate increased from ≤60 b.p.m. to >70 b.p.m.43

To assess the effect of heart rate on the consistency of 4-MDCT in quantifying coronary artery calcium, Hong et al.44 acquired two consecutive MDCT data sets on patients with various heart rates and found that variability between the two scans in the measurement of calcium score, volume, and mass increased with increasing heart rate. Thus, lower heart rates are associated with both better image quality and better reproducibility.

The advantages of a slower heart rate were also established for 16-MDCT. A study verified that the percentage of visualized vessel length was significantly higher in patients with a heart rate ≤60 b.p.m. (96%) compared with patients with a heart rate >60 b.p.m. (89%).20 Another study showed that image quality was uniformly high in all areas of both coronary arteries when heart rate was controlled with beta-blockade (Figure 7).45

**Use of beta-blockers**

Beta-adrenergic receptor blocking agents (beta-blockers) are recommended to reduce heart rate.39 Because patients referred for angiography often have persistent coronary disease requiring the use of beta-blockers, in many cases optimal imaging may be obtained with no change in medication. In several studies, >60% of patients referred for conventional selective coronary angiography were taking long-term beta-blockers, indicating that the majority of patients have an appropriately controlled heart rate.21,22,40 For patients not taking beta-blockers, short-acting beta-blockers are increasingly used to control heart rate and improve image acquisition.46 However, beta-blockers may slightly increase the risk of bronchospasm during the procedure.47 With the new 64-slice MDCT scanners, optimal studies may be performed at higher heart rates, but routine use of beta-blockers is still common in practice.

**Choice of CM**

The CM chosen for MDCT may increase the heart rate, thereby reducing image quality. There are differences between the types of CM available for use, which historically have evolved from a high-osmolar, ionic composition to a low-osmolar, ionic or non-ionic composition, and finally to an iso-osmolar, non-ionic composition. Over time, the osmolality of CM has steadily decreased with minimal effects on iodine content (Figure 8).48 The osmolality of a CM (the number of particles in a given volume) affects fluid movement in the body because fluid moves to areas of high particle concentration. Thus, fluid moves out of tissues and cells when high osmolar CM is in a blood vessel, causing local dehydration. Iodixanol, the only iso-osmolar CM (IOCM) currently available for intravascular use, is iso-osmolar with blood.

Numerous studies have found that more frequent changes in heart rate and blood pressure result from
the use of a high-osmolar CM (HOCM) than from the use of a low-osmolar CM (LOCM), particularly in patients with severe heart disease. In addition, in a double-blind, prospective study of 110 patients, ioxaglate, an ionic dimeric LOCM, increased heart rate to a greater extent than iodixanol, a non-ionic, dimeric iso-osmolar CM. This result was confirmed by a study of 102 patients given iodixanol and ioxaglate (Figure 9). Thus, compared with ioxaglate, the use of IOCM during MDCT may improve image quality by not increasing heart rate.

Observed changes in heart rate may be an indirect result of CM-induced lowering of blood pressure, which is more likely to occur in patients with severe coronary stenoses or myocardial insufficiency. In a crossover study of 48 patients with compromised left ventricular function, cardiac catheterization was performed with iodixanol (an IOCM) or iohexol (a LOCM), and the effect on left ventricular end-diastolic pressure (LVEDP) was measured. Although a non-significant decrease in LVEDP was observed with both agents immediately after injection, at 60–180 s after injection, LVEDP was significantly higher with iohexol ($P = 0.0012$). Because iodixanol resulted in a lower and shorter rise in LVEDP, iodixanol may be the safer alternative in catheterization procedures for high-risk patients.

Heart rate may also be influenced by patient discomfort and stress that in turn are affected by the choice of CM. Patients may report sensations of warmth or pain as CM is injected, depending on its composition. This pain is likely due to fluid movement from cells and tissues into the circulatory system when CM with an osmolality greater than blood is present. Injection-related pain and heat sensations are less frequent with the IOCM iodixanol during cardiac angiography procedures than with the LOCM iohexol (Figure 10), which has been confirmed in a number of comparative clinical studies.

The choice of CM also may affect the incidence of adverse coronary events in high-risk cardiac patients. The COURT trial (COntrast media Utilization in high-Risk PTCA (Percutaneous Transluminal Coronary Angioplasty)), performed in high-risk patients undergoing coronary artery intervention with iodixanol or ioxaglate, examined in-hospital major adverse clinical events. This study revealed a 45% reduction in in-hospital (or peri-procedural) major adverse clinical events in the iodixanol cohort. More recently, the results of the VICC (Visipaque vs. Isovue in Cardiac Catheterization) trial demonstrated a significant reduction in the number of peri-procedural myocardial events with iodixanol compared with iopamidol.

### Optimizing administration of CM

Use of iodinated CM during MDCT is essential for visualization of the lumens of the coronary arteries. With respect to imaging efficacy, various types of CM, including iodixanol and iopromide, have given satisfactory results with 16-MDCT. The method used to inject CM influences image quality. For example, the duration of the injection affects the degree of contrast enhancement and optimal scan timing. A fast injection of contrast followed by a slow injection can prolong contrast enhancement at the imaging site. For newer, faster scanners, optimal contrast enhancement is required for a shorter period of time, and a lower volume of CM can be used. For example, CT angiography with a 4-MDCT scanner requires $\sim 120$ mL of CM, whereas the same procedure with 16-MDCT requires only $100$ mL of CM. A 64-MDCT scan can be completed with $80$ mL of CM. Thus, optimized high-speed MDCT may require less CM than angiography.
However, the timing of the scan with respect to injection of CM is critical. The test bolus technique or computer assisted triggering can be used to determine the patient-specific delay time between injection of CM and arrival at the imaging site.

Injection of saline immediately after contrast injection (saline chaser) may improve image quality by increasing the amount of CM available for image acquisition and pushing the contrast bolus forward. Contrast can be washed out of the superior vena cava and right side of the heart, making visualization of the right coronary arteries much easier. An automatic dual-head power injector is required for administration of both CM and a saline flush.

The concentration of CM used may influence image quality. If the CM present in the lumen is too dense, it may be difficult to see plaque in the vessel wall or it may result in an artifact off of the vessel. A study demonstrated that high contrast concentration administered at high flow rates obscured detection of coronary calcifications. A somewhat lower contrast attenuation may be required to differentiate the different types of plaque present in the artery wall.

As MDCT scanners with better resolution are introduced into the clinic, the details of administering CM will be optimized and customized for each patient. Specific protocols are available online at http://www.ctisrus.com.

Conclusions

Cardiovascular imaging has tremendous potential for identifying patients with atherosclerotic disease likely to result in adverse cardiac events. MDCT is a non-invasive alternative to coronary angiography with high temporal and spatial resolution, particularly in newer scanners (64-MDCT). Instead of inserting a coronary catheter for selective dye infusion as in angiography, iodinated CM is infused intravenously through an ante-cubital vein. Using CT scanners with more than 16 rows of detectors, image data can be collected rapidly with good spatial resolution. With ECG-based algorithms, a specific time point at which most segments of the coronary arteries are observable can be chosen for optimal visualization. Results are comparable with those obtained with catheter angiography, though additional data on plaque composition can also be obtained with MDCT, which may identify patients with vulnerable plaques who are at risk for coronary events. Information such as cardiac dimensions, ejection fraction, and the condition of the aorta or pulmonary arteries can also be obtained in a single scan.

Optimization of heart rate is important to obtain high-quality results with MDCT. Heart rates >65 b.p.m. can increase motion artifacts and reduce the diagnostic quality of some portions of the coronary arteries. Heart rate can be controlled with the use of beta-blockers and by using the appropriate CM. An IOCM is less likely to affect cardiac function and stimulate the heart rate directly and to increase heart rate indirectly by increasing patient discomfort. Overall, an IOCM may result in a better imaging outcome than a LOCm due to slower heart rate, less patient motion due to discomfort, and fewer major adverse events.

With proper use of recently developed scanners, beta-blockers, and CM, MDCT can non-invasively and accurately provide important diagnostic information on the condition of the heart and its vessels. These findings should support appropriate treatment decisions to reduce the morbidity and mortality resulting from cardiac disease.

References

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