Coronary CTA

Indications, Patient Selection, and Clinical Implications

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Abstract: Recent technical advancements of modern multislice computed tomography scanners including improved temporal and spatial resolution allow for the evaluation of cardiac patients. These modern techniques have been applied to bypass imaging, assessment of pulmonary veins following ablative therapy, congenital and acquired anatomic abnormalities, and also the evaluation of coronary artery disease. Cardiac computed tomography angiography is a valuable tool for patients with equivocal stress test results or inconclusive echocardiography in patients with intermediate likelihood of coronary artery disease. Future applications of this study include coronary plaque imaging, triage of patients with chest pain in the emergency room, and evaluation of myocardial viability.

Key Words: coronary artery disease, multi slice computed tomography, chest pain, computed tomography, CT angiography

(*J Thorac Imaging* 2007;22:35–39)

Significant developments in cardiac computed tomography (CT) technology have occurred over the last several years. Manufacturers are continously updating improvements of the existing 64-slice technology. The latest release is dual source CT that now allows unprecedented acquisition times. Not only are technical advances influencing the value of cardiac CT but software developments as well. New clinical applications like cardiac function analysis and plaque imaging are becoming increasingly routine.

However, we are between Scylla and Charybdis. Every 26 seconds, an American will suffer a coronary event, and about every minute someone will die as a result of a coronary event. In 2005, the estimated costs of cardiovascular disease were $393 billion. Every year, an estimated 700,000 Americans have a new coronary attack. Approximately, 1.5 million inpatient heart catheterizations were performed in 2002. It is reported that only one-third of patients undergoing conventional angiography require some sort of an intervention, whereas two-thirds are performed for diagnostic purposes only.[1–3] A tool or a combination of tools that reliably and cost-effectively excludes or determines coronary artery disease (CAD) is required. Multislice CT has the potential to fill that position and to act as a filter before invasive heart catheterization.[4] Nevertheless, health care costs are rising from year to year and cardiac CT will challenge health care systems if used uncontrolled.

Cardiac CT is not limited to the imaging of the native coronary arteries. There are a variety of possible and established applications. The controlled utilization of these applications by outlining appropriate clinical indications along with rational patient selection is the objective of this article.

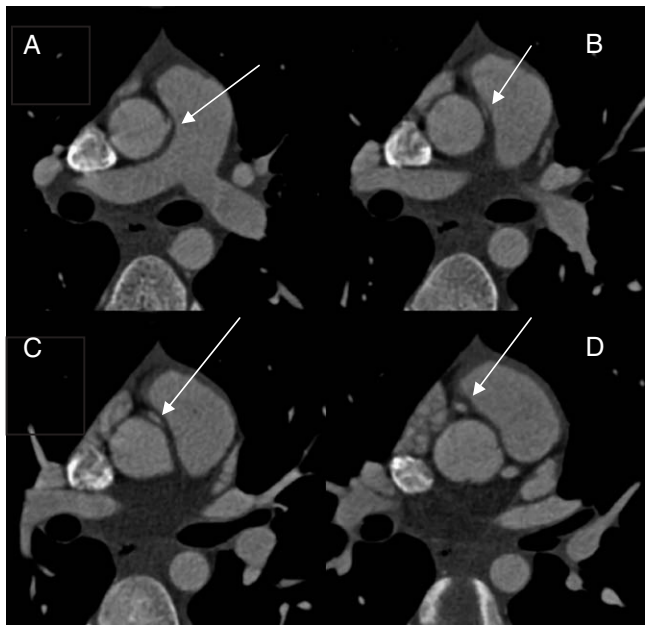

FIGURE 1. Axial images of a 22-year-old man with chest pain presenting to the emergency department. CTA revealed a malignant coronary anomaly with an acute angled take-off (A) of the right coronary artery between aorta and pulmonary trunk. The vessel travels in the anterior direction between aorta and pulmonary trunk (B, C) to its expected location (D).

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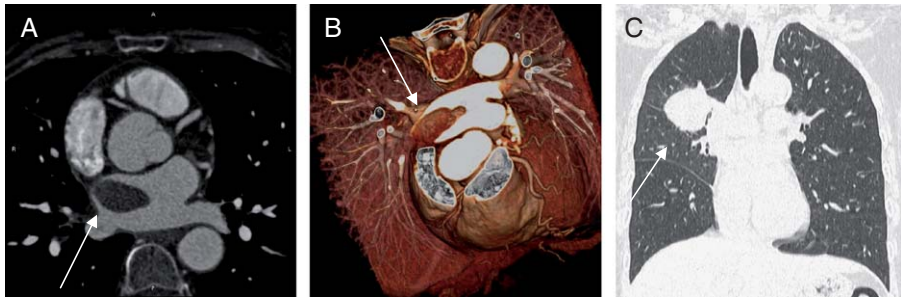

FIGURE 2. Axial (A), 3-dimensional reconstruction (B), and full view coronal multiplanar reformat (C) images of a 40-year-old woman with suspected thrombus in the left atrium at transthoracic ECG. CTA reveals tumor infiltration of the left atrium (A, B) via the right upper pulmonary vein from a lung cancer involving the right upper lobe (C).

EVALUATION OF CARDIAC MORPHOLOGY

Coronary Anomalies

The systemic administration of the contrast agent and high spatial and temporal resolution makes computed tomography angiography (CTA) the preferred modality to identify and evaluate abnormalities including anomalies of the coronary circulation, great vessels, valves, and heart chambers.

Origin and course of aberrant coronary arteries can be exactly visualized and classified in malignant (interarterial course between aorta and pulmonary artery) or benign (course behind the aortic root between aorta and left atrium or anterior to the pulmonary trunk). Malignant variants are considered to be linked to sudden cardiac death because the vessel can be squeezed during the cardiac contraction. In addition, the take-off from the aorta often has an acute angle, which is suspected to have an arrhythmogenic potential. Additionally, acute angulation has been shown to lead to premature atherosclerotic disease due to flow abnormalities (Fig. 1).

Cardiac Masses

Cardiac masses can be reliably assessed with cardiac CT with optimal visualization of adjacent structures, whereas transthoracic and transesophageal echocardiography (ECG) is not suitable for covering the entire thorax and is also operator dependent. While the visualization of the coronary arteries is sometimes hampered by artifacts or calcifications, the exact assessment of cardiac masses is always possible. With new generation scanners like dual source and dual energy CT technology, evaluation of tumor tissue may be possible in future (Fig. 2).

Pericardium

The evaluation of the pericardium is an important part of the CTA examination. Specific indications for pericardial assessment include identification of pericardial thickening and calcifications in the evaluation for constrictive pericarditis and also the identification of pericardial masses or fluid. Not only does CTA elucidate all of these indications in a single study but also includes additional information regarding the neighboring coronary arteries (distance from the calcification/mass, atherosclerotic disease) and the functional consequences.

PULMONARY VEIN ASSESSMENT

Both preoperative and postoperative pulmonary vein imaging in the context of radiofrequency ablation therapy for cardiac arrhythmia is considered an appropriate indication. The preoperative evaluation includes the assessment of the presence, location, and size of the pulmonary veins with the added information about the coronary arteries and cardiac function analysis. However, the examination of the coronary arteries may be hampered by the fact that most patients preoperatively may have cardiac arrhythmia. Software is available for the fusion of images combining anatomic and electrical information (electroanatomic mapping). Postoperative CTA is an established modality in many institutions in the assessment of pulmonary vein stenosis after ablation therapy (Fig. 3).

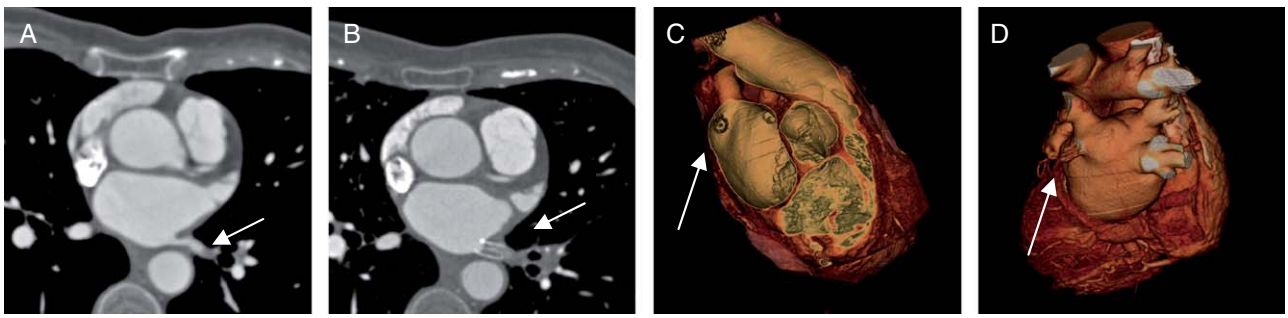

FIGURE 3. A, Axial CTA of a 67-year-old patient after radiofrequency ablation for atrial fibrillation. Image reveals stenosis of the left lower pulmonary vein. B, Axial image demonstrates subtotal occlusion of the subsequently implanted stent. C and D, 3-dimensional reconstructions (C: ''hollow view'') with display of the left atrium with subtotally occluded stent in the left lower pulmonary vein (arrow).

EVALUATION OF CAD BEFORE NONCARDIAC SURGERY

Although currently the role of preoperative CTA is still uncertain,[9] its potential before noncardiac surgery in an intermediate and high-risk population is being considered. Not withstanding the minimal risks related to radiation exposure and contrast administration, significant coronary artery stenosis can be excluded. In addition, cardiac function analysis including wall motion evaluation and prediction of the left ventricular ejection fraction can provide important information to the anesthesiologist.

BYPASS EVALUATION

CTA after bypass surgery can be considered in symptomatic patients to demonstrate graft patency or stenosis. There is no indication for bypass-CTA for asymptomatic patients[9] with the exception of preoperative planning. CTA before bypass surgery is not yet established but could be potentially useful in the evaluation of the atherosclerotic plaque burden of the aorta and the associated risk of cerebral ischemia.[11] Furthermore, detailed information about the location and size of the internal thoracic arteries can be given to the surgeon. The anesthesiologist can incorporate the functional data obtained from CTA into his or her practice to choose a safe anesthetic that would be appropriate for a given patient's cardiac status (Fig. 4).

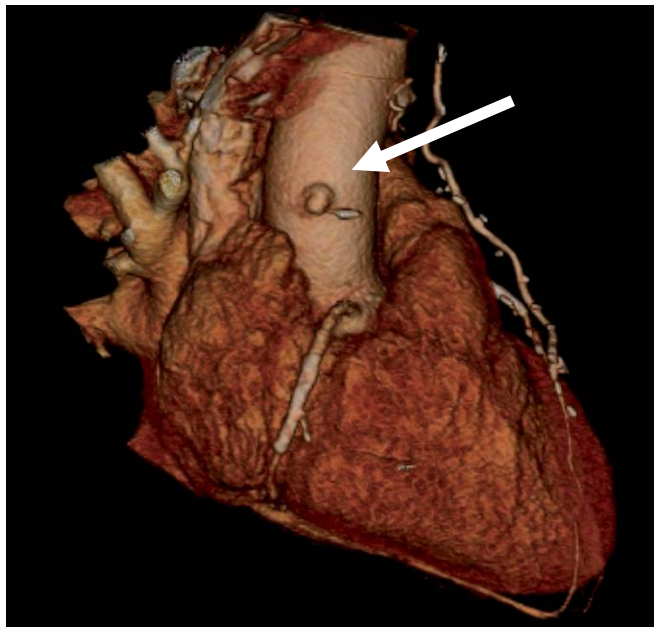

FIGURE 4. A 65-year-old male patient with bypass surgery 7 years ago now presenting with chest pain on exertion. The 3-dimensional reconstruction reveals a left internal mammary artery bypass to the left anterior descending artery. The distal native left anterior descending artery has good run-off and wraps around the apex of the heart. The native right coronary artery is heavily calcified in its mid portion. The coronary artery bypass graft intended to supply the right coronary artery is occluded and can only be identified by a nub on the lateral aspect of the ascending aorta (arrow).

DETECTION AND EVALUATION OF CAD

An essential role of cardiac CT is to reliably exclude CAD requiring intervention. The benefit of this modality is based on its ability to discern significant stenoses. Because of the limited resources in health care and additional exposure to contrast and radiation, it cannot be considered as a complimentary test. Rather it must have a future as a first line test to preclude cardiac catheterizations in a reasonable number of cases. The number of false positive CTA examinations should be considerably low; the number of false negative results must be zero.

The evaluation of patients with CP follows guidelines given by the American College of Cardiology and the America Heart Association.[5–7] Typical angina with ST segment elevations does not require cardiac CT but immediate reperfusion therapy (eg, heart catheterization). The modus operandi for patients with angina and non-ST segment evaluations differs and depends on the character of the chest pain (typical/atypical), the reaction of symptoms to antianginal therapy, and on the development of elevated cardiac enzymes. Cardiac CT is considered to be appropriate if ECG is unchanged or inconclusive and serial enzymes stay negative in stable patients with intermediate pretest likelihood of a coronary event. CTA is also appropriate in patients with chest pain unable to exercise or with uninterpretable or equivocal stress tests.

In the absence of ST segment elevations and positive biomarkers, CTA is a useful tool in clinical practice. In addition to the high negative predictive value of a negative calcium score, CTA can reliably exclude significant stenosis (Fig. 5).[8]

Asymptomatic Individuals

The usefulness of CTA in asymptomatic individuals is limited. Appropriateness criteria[9] assign only an uncertain value to high-risk individuals, whereas there is no indication seen in low or moderate risk patients. For the moderate risk group, the indication is considered uncertain in the case of an elevated coronary calcium score (Fig. 6).

CHEST PAIN—''TRIPLE RULE OUT''

Patients with unequivocal acute coronary symptoms with significant ST changes and/or elevated biomarkers are not eligible for cardiac CTA. However, the majority of patients in the emergency departments do not have clear cut signs of acute coronary symptoms.[2] Cardiac CT, commonly referred to as the ''triple rule out scan'' in this context, is in the process of being evaluated and

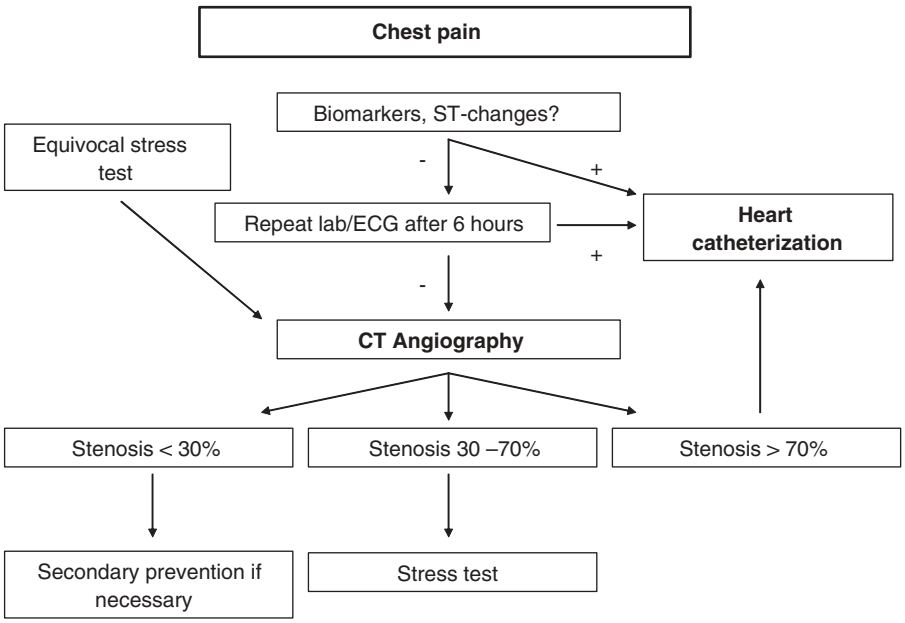

FIGURE 5. Algorithm for patients with chest pain and/or equivocal stress tests.

show promise in effectively clarifying many causes of chest pain including CAD, pulmonary embolism, aortic dissection, and other pathologies of the lungs and thorax.[10]

CONCLUSIONS

CTA with new generation scanners with high spatial and temporal resolution are capable of yielding comprehensive anatomic information of the coronary arteries, heart chambers, valves, and surrounding structures including lungs and thorax. Cross-sectional imaging has been recognized as the preferred diagnostic strategy for the evaluation of coronary artery anomalies, because the information obtained from volumetric imaging on the origin and anatomic course of aberrant vessels by far surpasses conventional angiography. Many applications like bypass and pulmonary vein imaging are already part of daily practice. The evaluation of CAD is improved with high acquisition times and ongoing advances in postprocessing software. Continuing technological developments will broaden the clinical utility of this examination resulting in indications that to date have not been fully realized.

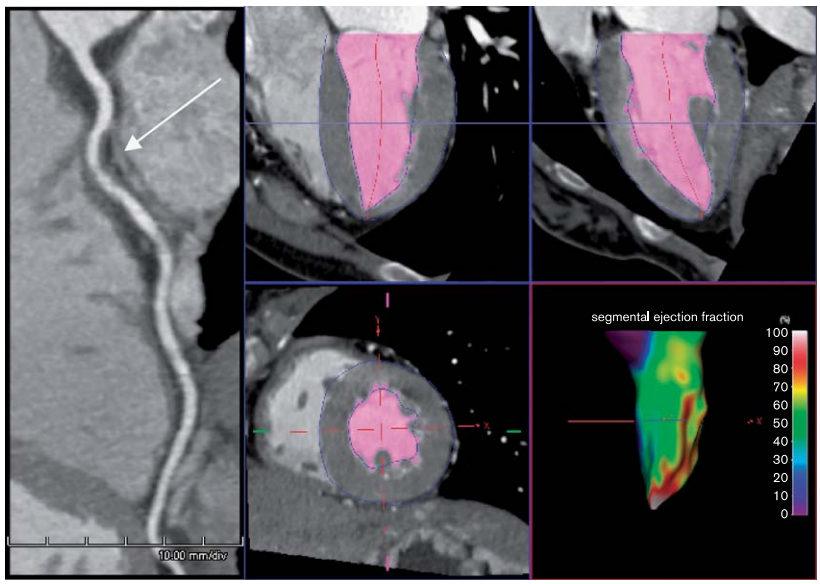

FIGURE 6. A 27-year-old-female with prior myocardial infarction of the left anterior descending artery and presentation with chest pain. Normal ECG and serial biomarkers. Left image: curved multiplanar reformat of the right coronary artery with demonstration of nonobstructive, noncalcified plaque. Right images: normal cardiac function with display of 2 long axis views (upper) and short axis view (lower left), and color coded segmental ejection fraction (lower right).

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