STATE-OF-THE-ART CARDIAC CT AT THE METHODIST HOSPITAL

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INTRODUCTION

The last decade has witnessed dramatic improvements in computed tomography (CT) technology. Developments have included increasing gantry speeds, addition of multiple thin detector arrays, and more sophisticated software processing for informative image displays. The results have been improved temporal resolution, near isotropic voxels for submillimeter spatial resolution, reduced image acquisition times, and lower radiation exposures with fast scan times.1 As a result, cardiac CT has evolved into a robust technology used to noninvasively assess cardiac structure and function, determine the presence and extent of coronary artery calcification (CAC) and noncalcified plaque, hunt for coronary anomalies, and provide a noninvasive coronary angiogram for diagnosing significant coronary artery disease (CAD} in native vessels or coronary artery bypass grafts (Figures 1-3).

Accompanying research literature has evolved at an equally dizzying pace. Whether experimenting with newer CT technologies, comparing them to other cardiac imaging modalities, learning to better characterize plaque, or changing acquisition parameters to reduce radiation exposures, CT is currently generating a level of excitement that is reminiscent of the 1970s, when echocardiography rapidly came into common clinical use.2 Cardiac computed tomography has the potential to revolutionize the current practice of cardiology for CAD detection and treatment, and it is expected that its use and development will continue to accelerate in the upcoming years.

The Methodist DeBakey Heart & Vascular Center (MDHVC) is actively committed to the research, clinical activity, and teaching of cardiac CT. Under the leadership of the center's medical director of nuclear cardiology John J. Mahmarian, M.D., two board-certified nuclear-CT cardiologists have come on board and two state-of-the-art multidetector CT (MDCI) systems dedicated to cardiac imaging are now place. Also, under Mahmarian, the clinical volumes have rapidly expanded to more than 400 cardiac cases per year. Every effort is being made to design, coordinate, and participate in research trials to advance this promising field while at the same time showcasing this robust tool to clinicians.

CT USE IN DIAGNOSING CHEST PAIN

Each year, more than five million patients present to U.S. emergency rooms (ER) for chest pain. Greater than 60% are eventually diagnosed as noncardiac chest pain but at a cost of between $10 to $15 billion dollars.3 The diagnosis of acute coronary syndromes (ACS) is missed in 2-4%, resulting in significant liability issues that contribute to the low threshold for hospital admission of patients with chest pain. The current clinical paradigm does not permit an effective ER triage of patients with acute chest pain in whom initial troponin levels are normal and ischemic ECG changes are not evident.

Recently, at the American Heart Association 2008 Scientific Sessions, our group demonstrated the value of noncontrast CT in such a population.

Figure 1. An example of coronary artery calcification in the left main, left anterior descending, and circumflex coronary arteries. **The** Agatston coronary artery calcium score is calculated based on **the** density and area of all observed calcified plaque.

In a study performed in 1,031 chest pain unit (CPU) patients, the relationship between noncontrast CT, stress myocardial perfusion single photon emission computed tomography (SPECT), and clinical cardiac events was observed. With increasing coronary artery calcium scores (CACS), both the percentage of abnormal SPECT exams and clinical events statistically increased. More interestingly, however, were the observations in 625 patients with a CACS of zero. These patients were found to have normal SPECT exams and an excellent shore-term outcome (Table 1).[4] This may pave the way for a new clinical algorithm that is simpler, efficient, and more cost effective in managing ER patients with chest pain. Another equally exciting study will be the comparison of SPECT versus CACS and CT angiography in a large cohort of

Coronary Artery Calcium Score (CACS)

	0 (N=625}	1-10 (N=87)	11-100 (N=136}	101-400 (N=100}	>400 (N=83)	p Value
Abnormal SPECT	5 (0.8%)	3 (3.4%)	9 (6.6%)	9 (9.0%)	14 (16.9%)	<.001
Cardiac Events	2 (0.3%)	0 (0%)	8 (5.9%)	8 (8.0%)	11 (13.2%)	<.001

Table 1. Results from our study evaluating low-risk chest pain patients with CACS.

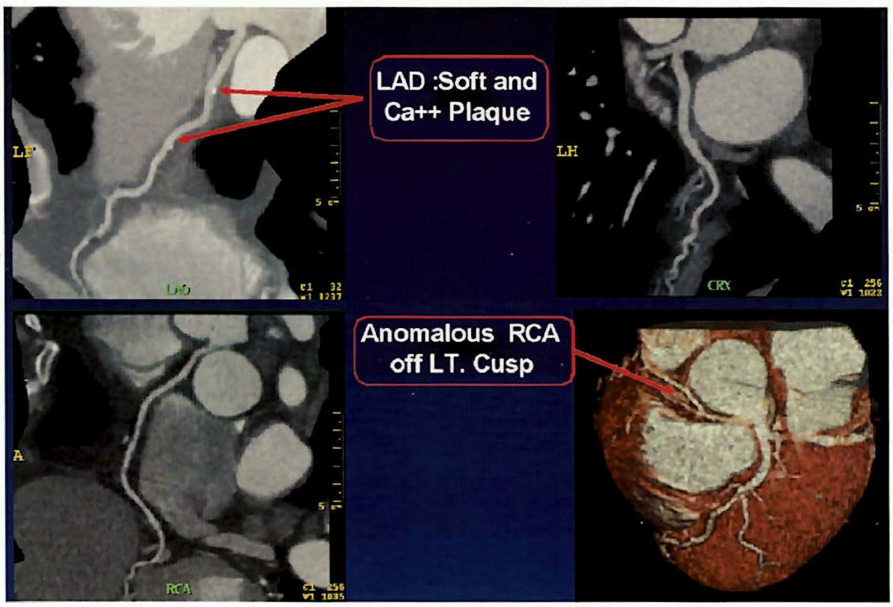

Figure 2. CTA demonstrating an anomalous right coronary artery (RCA) originating from the right coronary cusp and traveling interarterially. The left anterior descending (LAD) coronary artery has mild nonobstructive mixed plaque. Ca++ = calcified. (Images provided by John J. Mahmarian, M.D., F.A.C.C., F.A.S.N.C.)

low-risk chest pain patients. This study will help determine the efficacy, cost, and efficiency of each procedure in the diagnosis of coronary artery disease and acute coronary syndromes (ACS). Our continued efforts will be in creating the optimal clinical algorithm for risk-stratifying chest pain patients.

FUSION IMAGING WITH SPECT AND CT

Integrative hybrid imaging with SPECT and CT is also an avenue of continuous exploration. Both tests individually are powerful in predicting subsequent patient outcomes. Combining the two methodologies may provide further insight into the interplay between anatomic assessment of coronary atherosclerotic burden with a functional assessment of myocardial ischemia in predicting long-term risk and tailoring therapy. Recently, over a median period of 6.9 years, we followed 1,035 generally asympcomatic subjects without prior cardiovascular disease who had a CACS and SPECT performed within a close time period. The prevalence of an abnormal SPECT increased with increasing CACS. Also, both CACS and SPECT findings were found to be independent and complementary predictors of events. Most intriguing, however, was the finding that in patients with a normal SPECT, the addition of CACS added further incremental prognostic information by helping to identify a higher risk cohort. Our results will show that integrating these test results will better risk-stratify individuals and better predict long-term outcome.

In patients with a clearly abnormal SPECT, fusion SPECT-CT technology may be of significance.[5] Stress SPECT imaging is a time-honored technique for identifying myocardial ischemia; however, due co variations in individual patient coronary anatomy, it is imprecise at localizing ischemia to a specific vascular territory. This tends to be particularly true in patients with mulciple perfusion defects on SPECT who have both scinrigraphic scar and ischemia and in those with overlapping vascular territories. Fusion technology allows physicians to overlay the CT coronary angiographic images with the SPECT perfusion data to yield an accurate three-dimensional representation of the patient's anatomic and functional information (Figure 4). In ocher words, chis new technology allows physicians to precisely define which coronary artery supplies a specific area of dhe myocardium so they can better tailor PCI procedures. The Methodist Hospital is currently one of only a handful of centers where fusion imaging with SPECT and CT is currently available.

A study is currently underway co address whether fusion-directed PCI can comparably reduce coral and ischemic left-ventricular perfusion defect size, at less cost, as compared to standalone SPECT. Finally, as SPECT incorporates hot spot imaging of atherosderotic plaque, an anatomic roadmap will be necessary to localize rhese scintigraphic occurrences, and fusion imaging will again be at a forefront. It may well be that patients who have myocardium supplied by arteries with

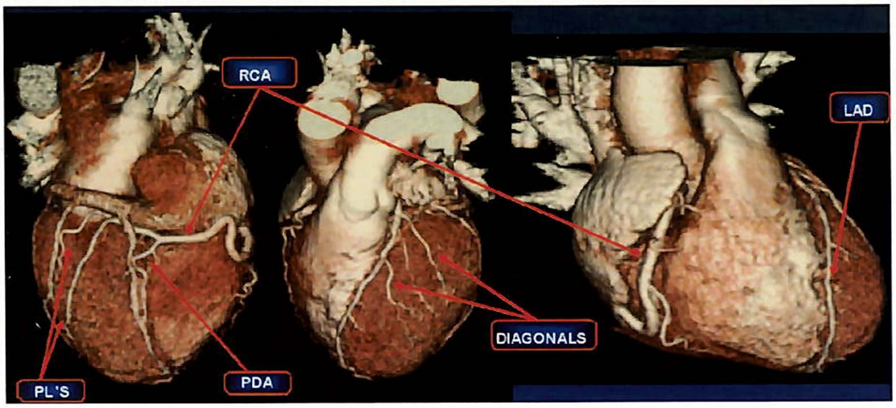

Figure 3. Volume rendered images showing the clarity that can be achieved with CTA. PDA = posterior descending artery; PLS = posterolateral branches; other abbreviations as in Figure 1. (Images provided by John J. Mahmarian, M.O• F.A.C.C., F.AS.N.C.)

high-risk features identified either by CT or SPECT may be more likely ꝏ benefit from intensive medical therapy and/or intervemional therapies. In the next decade, che goals offusion imaging will be to more precisely tailor therapy, reduce healthcare costs, and improve patient outcomes.

CONCLUSION

The groundwork of and commitment ꝏ cardiac CT are firmly established here at The Methodist Hospital. Our aim will be ꝏ continue to foster cutting-edge research, provide useful imaging information ꝏ referring physicians, and provide effective teaching of this new modality to future generations of new physicians.

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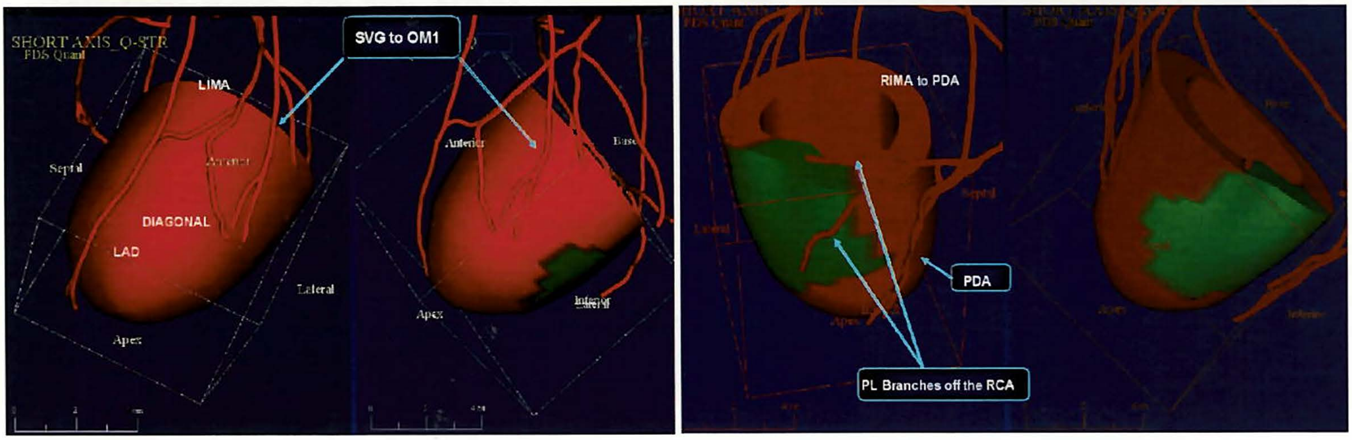

Figure 4. Example of CT-SPECT fusion imaging showing an ischemic inferolateral wall served by posterolateral branches from the RCA. IMA"' internal mammary artery; L"' left; OM1 =first obtuse marginal; R=right; SVG =saphenous vein graft. Other abbreviations as in previous figures.5