Editorial

New Toys for Nuclear Cardiologists

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Gordon Liljestrand is credited with establishing modern nuclear cardiology as a noninvasive imaging modality in 1939.1 Table summarizes major technological advancements in myocardial perfusion imaging over the past 70 years that have led to more accurate assessment of coronary artery disease (CAD). Most of these technical advances have involved radioisotopes and computer software. Camera hardware has undergone relatively little change since the introduction of the gamma camera, also commonly referred to as the scintillation camera, by Hal Anger in 1958.2 The gamma camera has performed admirably as the workhorse for myocardial perfusion imaging over the years but has several limitations. Sensitivity and resolution are modest. Imaging is inefficient as the heart occupies only a small portion of the field of view. Imaging places several demands on the patient, requiring relatively long imaging times (8 to 12 minutes) while lying motionless on a narrow, hard table with one or both arms fully abducted to minimize the distance between the patient’s chest and the rotating detectors. The relatively long imaging times require administration of fairly high doses of radioisotopes with attendant higher radiation exposure, an issue of increasing medical and societal concern.3

In the past few years, there have been tremendous advances in gamma camera technology due to the replacement of the conventional sodium iodide (NaI)-based systems with solid-state detectors using cesium iodide coupled to photodiodes or novel semiconductor-based detectors using cadmium zinc telluride (CZT). The most promising of these new technologies is the CZT detector, which directly converts gamma radiation to an electronic pulse and thereby eliminates the need for a scintillating crystal and photomultiplier tubes. The CZT detector is substantially smaller than a NaI-based detector. In addition, the CZT detector offers substantially better energy resolution and spatial resolution than the NaI detector. Because of its compact design, new, innovative detector configurations can be used that enable multiple independent detectors to be positioned around the patient. With multiple detectors focused only on the heart, image quality is improved due to the improved sensitivity in detection of activity in the heart. The most obvious direct benefits to the patients are shorter imaging times, which can be reduced by a factor of 5 or greater and require only 2 minutes, and reduced radiation exposure due to smaller administered doses of radioisotope.

Currently, there are 2 commercially available ultrafast camera (UFC) systems: the General Electric (GE) Healthcare Discovery NM 530c4–6 or Spectrum Dynamics D-SPECT. The detector configurations used in these UFC systems differ substantially, but they both have in common the use of multiple CZT detectors in place of NaI crystals. Both systems also apply either a wide cushioned table or a cushioned chair to support the patient during imaging in place of the narrow hard tables used by conventional imaging systems.

Claims of reduced imaging times, lower radiation exposure, and increased patient comfort are desirable but by themselves cannot be used to justify replacing conventional cameras with UFCs if imaging quality is sacrificed. To evaluate this issue, several studies have been performed using the GE Healthcare Discovery NM 530c4–6 or Spectrum Dynamics D-SPECT7–10 to compare images acquired by a UFC to those acquired by a conventional gamma camera. All of these studies reported comparable myocardial perfusion image quality with the benefit of significantly shorter image acquisition times. Some of these studies4,6,8,10 also evaluated left ventricular ejection fraction and volumes and reported similar results between the UFC and conventional systems.

Although these studies focused on demonstrating comparable imaging results between UFCs and conventional cameras, any observer who has had the opportunity to directly compare images acquired using both approaches in the same patient is impressed by the general superior image quality of the UFC system. In most patients, the images appear sharper with more precise edge definition. In this issue of Circulation: Cardiovascular Imaging, Gimelli et al11 sought to determine whether this improved image quality translates into more accurate assessment of patients with CAD. These investigators evaluated 34 patients who underwent 1-day low-dose (370 MBq) stress/high-dose (740 MBq) rest Tc-99m tetrofosmin conventional and UFC SPECT. Images were interpreted both subjectively by applying the standardized 17-segment model scoring system and objectively by using normalized polar maps. Global and segmental radiotracer uptake were quantified. Coronary anatomy was assessed in all patients by quantitative invasive coronary angiography (n=27) or 64-slice CT angiography (n=7). Twenty-nine of the patients had significant CAD, including 9 with 1-vessel, 11 with 2-vessel, and 9 with 3-vessel CAD.

In the overall per-patient analysis based on the summed stress score, there was a trend toward a higher area under the receiver operating characteristic curve for UFC versus conventional SPECT (98% versus 86%; P=0.078). By individual vessel analysis, the area under the curve was significantly

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higher for UFC for the left circumflex artery (97% versus 85%; \(P=0.039\)) and right coronary artery (99% versus 88%; \(P=0.045\)) territories. In the 29 patients with CAD, mean summed stress score was significantly higher for UFC versus conventional SPECT (10.1±4.4 versus 6.4±2.9; \(P=0.001\)). By quantitative analysis, mean tracer uptake on the stress images in each coronary territory was significantly lower by UFC SPECT (left anterior descending artery, 60±2% versus 70±3%; left circumflex artery, 65±4% versus 73±4%; right coronary artery, 63±5% versus 71±2%; \(P<0.001\) for all comparisons). Analysis of the gated images revealed similar values by each method for stress left ventricular ejection fraction and volumes.

This study by Gimelli et al\(^{11}\) is the first publication to compare UFC versus conventional SPECT using coronary angiography as the gold standard in a group of patients. Our nuclear cardiology laboratory has acquired experience with both the GE Healthcare Discovery NM 530c and the Spectrum Dynamics D-SPECT cameras. The results of the present study confirm our subjective impression that these UFC systems more accurately identify perfusion defects. We have had the opportunity to directly compare in a side-by-side manner SPECT images acquired with a conventional NaI system to the images acquired with both of these new UFC systems. We have seen several instances where equivocal perfusion defects on the conventional system that we would have passed off as imaging artifacts appear as real defects on the UFC systems and are confirmed as secondary to CAD on subsequent cardiac testing. The higher-count statistics with better image resolution and improved image contrast should lead to higher test sensitivity with UFC systems. Sometimes, better sensitivity is achieved at the cost of poorer specificity; however, with the UFC systems, specificity also appears to be improved. A major cause of false-positive studies is image artifacts. The improved energy resolution of the UFC systems also should result in less scatter in the image data. Anecdotally, we have seen spectacular image quality in some very obese patients. The shorter imaging times with more comfortable table or chair designs should lead to less motion artifacts. One standard approach to address imaging artifacts is to image patients in multiple positions. Although prone imaging has been available for years, it is not commonly performed because of time constraints and patient comfort issues. The very short imaging times provided by UFC systems substantially facilitate imaging patients in multiple positions. Using combined supine and upright imaging with the Spectrum Dynamics D-SPECT camera provides more accurate results than imaging patients in either I of these positions alone.\(^{12}\)

The study by Gimelli et al\(^{11}\) does have limitations. The study group was small. A minority of patients underwent only CT angiography, a highly sensitive technique but, nonetheless, not as accurate as the gold standard of invasive coronary angiography. Eighty-five percent of the patients had significant CAD, reflecting a highly selected patient population. It is conceivable that UFC systems may not be superior to conventional cameras in lower-risk populations where a much greater percentage of the population will have normal images. Clearly, more studies are needed.

Despite these limitations, Gimelli and colleagues have made a significant contribution by generating data to support the general subjective impression that UFC systems provide not just comparable, but better and more accurate SPECT images compared to conventional systems. The characteristics of UFC systems should result in better diagnostic sensitivity and specificity. The short imaging times provide nuclear cardiology laboratories with greater flexibility to optimize the SPECT study to the individual characteristics of the patient. For instance, in a younger patient where radiation exposure is a primary concern, a lower dose of a radioisotope with a lengthening of imaging time to achieve adequate count statistics could be the protocol of choice. However, in an elderly patient who has difficulty holding still, a higher dose of radioisotope (radiation exposure much less a concern) with short imaging times could be the preferred approach. The short UFC imaging times also have the potential to facilitate dual isotope imaging\(^{13}\); to apply SPECT imaging to optimize pacing parameters for cardiac resynchronization therapy\(^{14}\), and, theoretically, to quantitate myocardial blood flow.\(^{15}\)

Everyone loves a new toy. An old toy may seem perfectly adequate until compared to a new one, when it quickly loses its luster and appeal. In the movie Toy Story, it did not take Andy long to replace Woody with Buzz Lightyear.\(^{16}\) Nuclear cardiologists will undoubtedly be eager to replace their old Anger camera with a UFC model.

**Disclosures**

The Mayo Clinic Nuclear Cardiology Laboratory received research funding to support studies to validate the GE Healthcare Discovery NM 530c camera. Drs Miller, Askew, and O’Connor participated in these studies.

**References**


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