SPECT for Evaluating Myocardial Blood Flow

Cardiac SPECT studies remain an important first-line diagnostic imaging test for many cardiologists, internists and family doctors. Cardiac SPECT studies range from 80% of studies in outpatient clinics to about 40% in the hospital setting where many patients with non-cardiac disease are evaluated.[1]

The University of Ottawa Heart Institute (UOHI) is a world-renowned institution and Canada's largest and foremost heart center dedicated to understanding, treating and preventing heart disease. Terrence Ruddy, MD, FRCPC, FACC, Director of Nuclear Cardiology and Professor in the Division of Cardiology in the Department of Medicine, and Glenn Wells, BsC, MSc, PhD, FCCPM, Associate Professor in the Division of Cardiology and Medical Physicist in the Department of Nuclear Cardiology, UOHI, have been evaluating the use of Discovery™ NM530c, a solid-state Cadmium Zinc Telluride (CZT) detector system, in myocardial blood flow (MBF) and myocardial flow reserve (MFR) studies.

Historically, PET has been utilized for MBF studies in large part due to the inability of the traditional SPECT system to provide the needed temporal imaging speed and count sensitivity required for this type of exam. Ongoing studies by Dr. Ruddy's research group and others have demonstrated that CZT technology can provide MBF data similar to PET results.

There are two key trends impacting medical imaging and specifically SPECT imaging, explains Dr. Ruddy. One direction is the goal of lower radiation doses for all imaging studies that utilize either ionizing or injected radiation doses. Second is the desire to reduce scan time, which can enhance patient comfort and provide economic value to the center by enabling higher patient throughput and imaging capacity.

"We can address both of these trends with the CZT camera," Dr. Ruddy says. "To some degree, we can halve the dose and shorten imaging time, depending on the patient and their condition."

For example, in an 80-year-old patient, shorter scan times may be more advantageous than lower dose due to the patient's inability to remain still for any length of time. Conversely, dose reduction is more important in a 50-year-old patient with a longer probable life span and greater ability to lie still for an imaging exam. Of course, clinicians can elect to balance dose reduction and scan time to realize benefits on both ends.

According to Dr. Wells, a typical cardiac SPECT acquisition on Discovery NM530c takes half the time as on a traditional gamma camera. Initially, exams were performed at an average of 4 minutes. Then, Dr. Wells and Dr. Ruddy began evaluating the use of lower dose. Previously, traditional cardiac SPECT perfusion studies ranged from 10-20 mSv, depending on the patient's body habitus and other factors. Today, cardiac SPECT studies on the CZT camera at UOHI routinely use a "half-dose protocol" of 5 mSv and, to compensate for the lower dose, a slight increase in scan time.

"On the CZT camera at UOHI, a cardiac SPECT acquisition is approximately 8 minutes at half the dose compared to 15 minutes on a conventional SPECT camera," he adds. "This gives us both dose reduction and shorter scan time for a better patient experience."

"With an 8-minute scan time, our motion artifacts are also less prevalent," adds Dr. Ruddy.

In fact, Dr. Wells did some internal studies on scan times to see how long a person could typically remain still. He found the average "sweet spot," where a majority of patients undergoing an imaging exam did not move, is 7 minutes.

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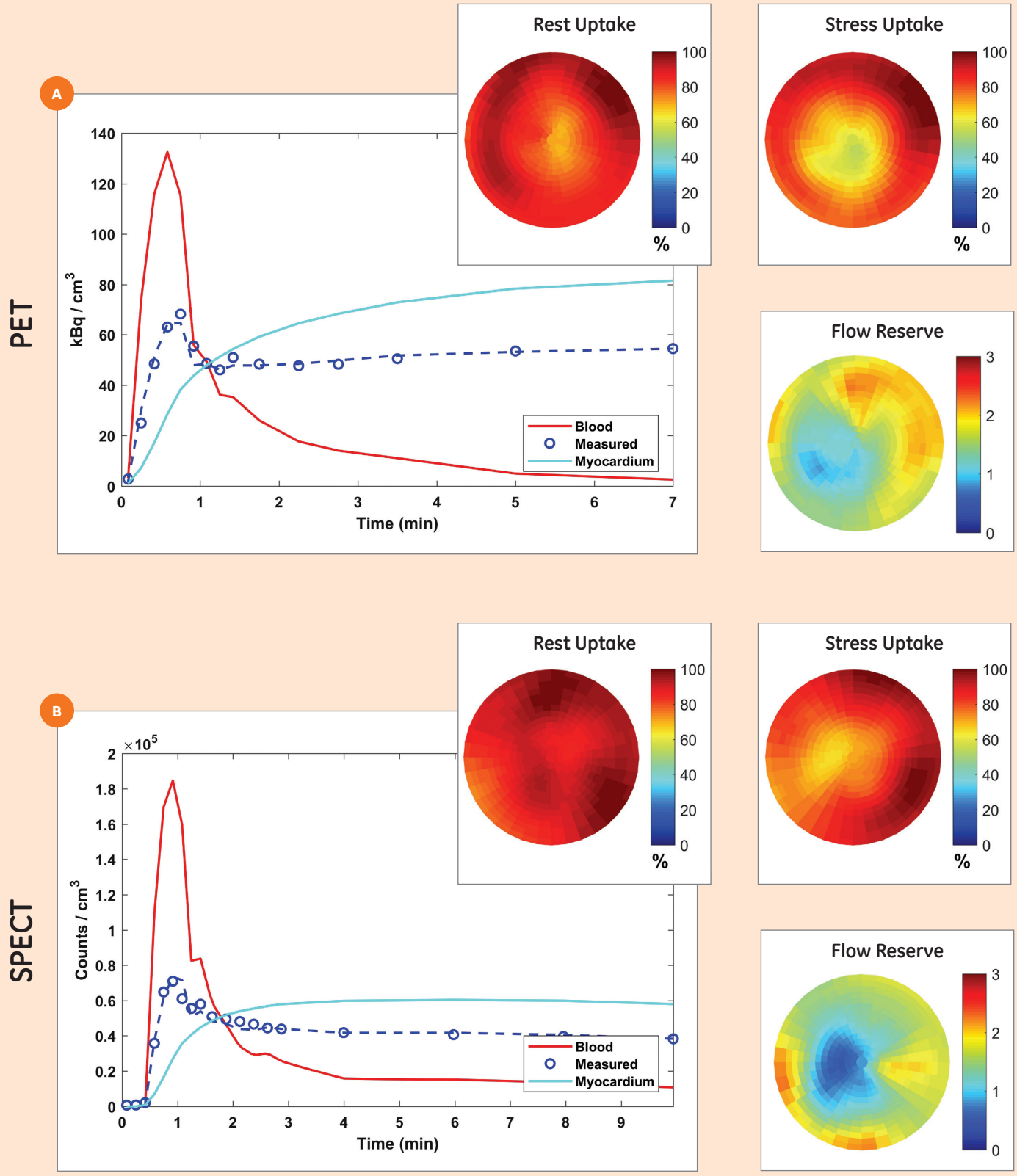

Figure 1. SPECT myocardial flow reserve: Relative perfusion images with (A) ^{82}Rb PET and (B) ^{99m}Tc-tetrofosmin SPECT in the same patient show only mild reduction in percent uptake of tracer at stress with apparently normal resting images. Time-activity curves from dynamic imaging (stress curves shown) allow calculation of absolute myocardial blood flow and flow reserve. The flow reserve is globally reduced (<2), indicating the presence of triple-vessel disease.

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SPECT MBF

For cardiologists, absolute MBF and MFR provide additional diagnostic and prognostic information on a patient's heart condition beyond relative perfusion. While absolute MBF has traditionally been performed on PET scanners, Dr. Wells, Dr. Ruddy and colleagues demonstrated for the first time in a 2014 preclinical porcine study the feasibility of measuring absolute MBF and MFR using a stationary dedicated cardiac camera, the Discovery NM530c, to perform dynamic SPECT.[2] Three common SPECT tracers were utilized for the rest and stress study: ^{201}Tl, ^{99m}Tc-tetrofosmin and ^{99m}Tc-sestamibi.

Dr. Wells explains the study compared two physiological states: stress and rest. To capture absolute MBF imaging data, a series of images are captured as the tracer is distributed throughout the body. "We need good temporal resolution to do this, and the CZT camera makes it easier to capture this data with the stationary detectors and delivers increased sensitivity for high-quality and accurate representation of blood flow."

With the stationary detectors that are more similar to the configuration of a PET scanner than a SPECT camera, the researchers could utilize validated PET protocols as well as post-processing PET software tools for data analysis.

"The ability of MBF to enable clinicians to detect abnormal blood flow in all three vessels can lead to better disease prediction in areas that appear normal on standard relative perfusion," Dr. Ruddy adds. He explains that medical management may be preferred in patients with single-vessel disease, while those with multi-vessel disease may be at a higher risk for an adverse event and may benefit more from revascularization with coronary stenting or bypass surgery. With the knowledge of absolute MBF, clinicians can make more informed patient management decisions that can reduce costs downstream and optimize patient care.

"We have seen several patients with apparent limited one-vessel coronary artery disease on usual relative perfusion imaging, but they had multi-vessel disease as shown by MBF data, requiring a more aggressive and appropriate therapy given the extent of the disease," Dr. Ruddy explains.

Attenuation correction (AC) and scatter correction (SC) were also evaluated in this study. While both can improve the accuracy of the image, they can also increase image noise. "In this study, we found that if we are looking at the global flow of the entire heart, then we may get imaging data that's just as good without attenuation correction as we did with it," Dr. Wells says. "However, as we imaged smaller areas in the heart, for example each of the tree territories—the LAD, RCA or LCX—there was a greater benefit to using AC. We found that it was more important to utilize AC in smaller heterogeneous regions, therefore a CZT technology where there is an option of using external CT for AC may be of greater benefit."

The importance of this study is underscored by the global incidence of heart disease, escalating healthcare costs and the continued need for prognostic and predictive data in cardiac patient management.

"SPECT MBF can provide the data that cardiologists can use to help determine if a patient should undergo angiography and revascularization or can be safely treated with more conservative and less expensive medical management," Dr. Ruddy says. Considering that SPECT is a less costly system to purchase than PET and is more readily available in clinics and centers around the world, then it is likely that absolute MBF studies will be performed on highly sensitive and robust SPECT CZT scanners such as Discovery NM530c. ■

References

1. IMV 2013 Nuclear Medicine Market Outlook Report. Available at www.imvinfo.com.
2. Wells RG, Timmins R, Klein R, et al. Dynamic SPECT Measurement of Absolute Myocardial Blood Flow in a Porcine Model. J Nucl Med. 2014;55:1685-1691.