Leveraging Inherent CZT Properties on Discovery NM530c for Dual-Isotope Imaging

Nuclear medicine (NM) gamma cameras have long been utilized for evaluating myocardial perfusion in cardiac patients. Recent advancements in NM imaging technology, including the introduction of a Cadmium Zinc Telluride (CZT) detector and hybrid (NM/CT) systems, have created new opportunities for exploring the use of NM systems for other indications, clinical areas and in research.

For example, CZT is an enabling technology that allows for the exploration of inflammation and infection. It is also ideal for dual- or multi-isotope imaging. According to Professor Frank Bengel, MD, Director of the Department of Nuclear Medicine, Hannover Medical School (Hannover, Germany), cardiovascular infections such as endocarditis are key clinical issues that dual-isotope NM imaging can help address.

Hannover Medical School is one of the largest academic medical centers in Germany with a long history in NM imaging. According to Professor Bengel, the institution is one of the "birthplaces" of NM in Europe.

In addition to a PET/CT scanner, cyclotron and a radionuclide therapy center, the Department of Nuclear Medicine has two SPECT/CT cameras, three gamma cameras and the CZT-based Discovery™ NM530c cardiac camera.

In a recently published study by Professor Bengel and colleagues at Hannover Medical School, simultaneous multi-isotope imaging using Indium-111 (^{111}In) and Technetium-99m (^{99m}Tc) was found to aid in the work-up of patients with suspected endocarditis. Further, the study concluded that the use of a CZT detector improved the accuracy of molecular/cellular cardiac imaging.[1]

"For the dual-isotope study, we used Indium 111 and Technetium-99m, which have gamma peaks that are relatively far apart," Professor Bengel explains. "Using CZT detector technology made it relatively easier to sort out the two signals in the study and we were able to show the feasibility of simultaneous dual-isotope imaging.

"I am convinced from the results of this study that to be successful with dual- or multi-isotope imaging, it would have to be with the CZT camera," he says. CZT has a high energy resolution and provides higher maximum count rate and spatial resolution compared to conventional NaI-based SPECT or SPECT/CT systems that have suboptimal energy resolutions and require extensive corrections.

The Discovery NM530c is a very robust camera that accelerates imaging and provides added flexibility, Professor Bengel explains. The greatest impact he sees is the ability to scan faster and/or reduce the injected dose—both important benefits for patients—without affecting image quality. For example, with the CZT camera a 20 minute conventional cardiac SPECT study can be completed in as little as 4-5 minutes. He hopes that with the next generation of general purpose CZT systems, it will be possible to complete a whole-body SPECT in as little as 10 minutes[2]—far less than the typical 45 minutes. In addition, this may enable the exploration and development of new diagnostic tests using dual-isotope imaging in organs other than the heart.

"Dual-isotope imaging is a significant step forward in the diagnosis of endocarditis," Professor Bengel says. Using a second isotope, ^{99m}Tc, he can identify the myocardial valve plane from the myocardial perfusion study simultaneously in the same acquisition as the ^{111}In–labeled white blood cells that identified the inflamed hot spot, indicative of endocarditis. This, he says, dramatically increases clinical confidence, especially in the setting of valvular implants where other techniques such as echocardiography are often are less reliable.

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Clinical Cases

Figure 1 demonstrates the value of dual-isotope imaging for the detection of endocarditis. Two patients had previously received valvular implants and developed fever and symptoms suspicious of endocarditis. Antibiotic treatment was given in both cases but symptoms persisted. Echocardiography was equivocal and complicated by the implant material. The positive diagnosis in case (A), along with resistance to antibiotic treatment, lead to surgical revision of the valvular implant, where inspection and histologic analysis confirmed the diagnosis of bacterial endocarditis. The negative scan in case (B) lead to the clinical decision to continue antibiotic treatment and to search for underlying causes other than endocarditis.

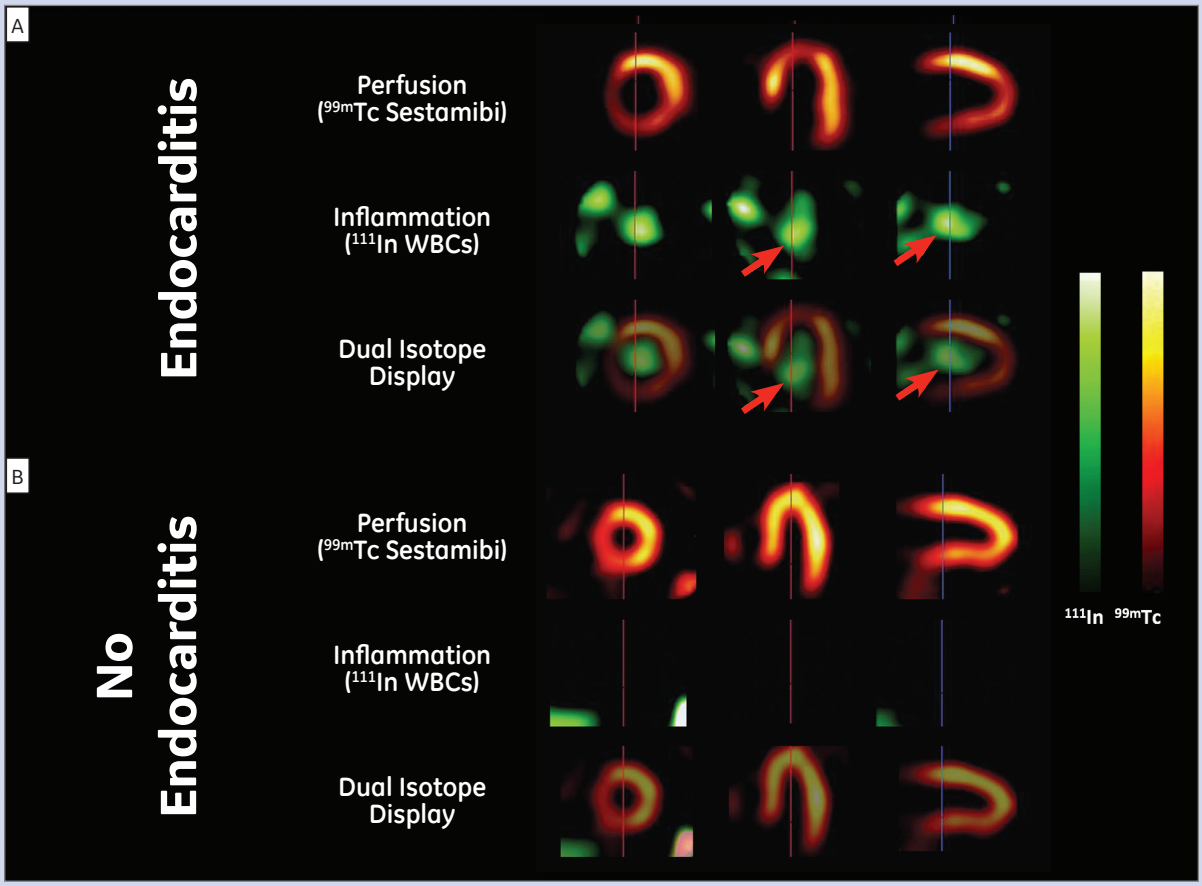

Figure 1. Simultaneously acquired dual-isotope CZT SPECT images in a patient with (A) and without (B) confirmation of suspected prosthetic valve endocarditis. (A) shows a hot spot of ^{111}In-labeled white blood cells (WBCs; green color, marked by arrows), merging to the valve plane on ^{99m}Tc perfusion images (orange color). (B) shows absence of inflammatory foci in the cardiac region.

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Conventional SPECT cameras do not provide this same level of confidence, he adds, particularly when targeting small anatomy such as myocardial valves due to the potential for misalignment without any additional structural imaging. Further, while PET is a useful diagnostic tool in these cases, Professor Bengel says that its specificity can be limited by artifacts due to metal implants or a non-specific signal from FDG accumulation in other non-inflamed tissue. Plus, from his experience in a busy academic medical center, it can often be difficult to schedule cardiac cases on a PET/CT scanner that is usually booked with oncology cases.

Professor Bengel is also interested in studying SPECT imaging with CZT compared to PET. While PET is more accurate than SPECT, he believes that CZT imaging will be closer to PET in terms of diagnostic performance. Adding CT to a CZT camera may further enhance diagnostic capability, not necessarily for cardiac imaging but for other areas and diseases throughout the body, he adds.

"I can foresee that for general purpose SPECT with a CZT camera, adding CT will be very helpful in general, not only for dual-isotope imaging techniques," Professor Bengel says.

Professor Bengel sees the future of NM in molecular imaging. CZT can help enable the simultaneous identification of one or more molecular mechanisms with a high degree of accuracy, he explains. As a result of on-going research, Professor Bengel believes it may even go beyond the diagnostic capabilities of PET by enabling multi-isotope imaging—made possible due to the array of SPECT tracer energies.

He further believes that the success of CZT will be in multi-isotope imaging for detecting inflammation and infection in combination with SPECT perfusion studies. Another area is in brain imaging, such as examining pre- and post-synaptic neurotransmission. His department has conducted several phantom studies looking at three isotopes simultaneously with success.

"The technology is exciting—the more scans we do, the more relevant our investment becomes," he adds. "CZT will enable us to push beyond the limits of traditional gamma cameras. New approaches in NM will change clinical practice and CZT will most likely be a key part of that—especially as we explore quantitative and dual-isotope imaging. All of which will lead to the expansion and utilization of SPECT imaging". ■

1. Caobelli F, Wollenweber T, Bavendiek U, et al. Simultaneous dual-isotope solid-state detector SPECT for improved tracking of white blood cells in suspected endocarditis. Eur Heart J. 2016 Jul 28. DOI: http://dx.doi.org/10.1093/eurheartj/ehw231 ehw231 First published online: 28 July 2016

2. In clinical practice, Evolution options[2a] (Evolution for Bone, Evolution for Cardiac, Evolution for Bone Planar) and Evolution Toolkit[2b] are recommended for use following consultation of a NM physician, physicist, and/or application specialist to determine the appropriate dose or scan time reduction to obtain diagnostic image quality for a particular clinical task, depending on the protocol adopted by the clinical site.

2a. Evolution Options – Evolution claims are supported by simulation of count statistics using default factory protocols and imaging of 99mTc based radiotracers with LEHR collimator on anthropomorphic phantom or realistic NCAT – SIMSET phantom followed by quantitative and qualitative images comparison.

2b. Evolution Toolkit – Evolution Toolkit claims are supported by simulation of full count statistics using lesion simulation phantom images based on various radiotracers and collimators and by showing that SPECT image quality reconstructed with Evolution Toolkit provide equivalent clinical information but have better signal-to-noise, contrast, and lesion resolution compared to the images reconstructed with FBP/OSEM.