General Purpose CZT Detector Represents a New Era in Nuclear Medicine

As the recipient of the first CZT-based general purpose SPECT/CT scanner, the Discovery™ NM/CT 670 CZT, at Rambam Medical Center (Haifa, Israel), Professor Zohar Keidar, MD, PhD, Deputy Director, Department of Nuclear Medicine, has extensive experience imaging with this next-generation detector technology. Rambam was also the first institution to utilize the Discovery NM/CT 570c, a dedicated cardiac scanner.

According to Professor Keidar, the Discovery NM/CT 670 CZT is having a major impact in terms of workflow and patient comfort and it also seems to provide the opportunity to optimize scanning time or injected dose. Dr. Keidar looks forward to exploring this opportunity to tailor the patient imaging protocol while maintaining image quality by reducing the dose with the same scan time, maintaining the same dose with a shorter scan time, or using a combination of both. It all depends on the patient whether to lower the dose and thus the radiation exposure or to shorten the scan and make the procedure more comfortable for someone who cannot lie for a long time.

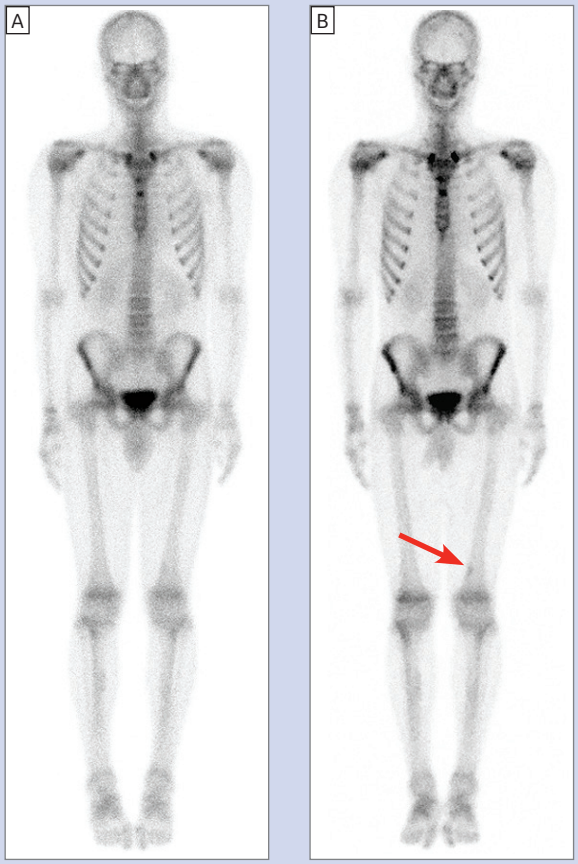

Figure 1. An 18-year-old male, 175 cm, 63 kg, with suspected stress fractures. (A) Patient was injected with 25 mCi Tc99m-MDP and scanned using whole-body planar imaging. (B) Patient was then scanned on the Discovery NM/CT 670 CZT with the same acquisition protocol and no additional tracer injection. The lesion (red arrow) is visualized in the CZT detector image.

Images courtesy of Rambam Medical Center, Haifa, Israel.

"With the CZT-based cardiac scanner, we can reduce the scan time by a factor of five," Professor Keidar says. "Instead of 15 minutes, the scan is time is three minutes. That's a big difference for a patient who can't raise their arm up over their head for a long period of time."

This improvement in workflow has allowed Rambam to replace two older nuclear medicine scanners with just one Discovery NM/CT 570c, making it a sound investment.

So when Professor Keidar was tapped to evaluate the first CZT-based general purpose nuclear medicine camera, he already had high expectations. He wasn't disappointed.

"Our initial experience shows that the image quality and resolution is as good as the Discovery NM/CT 670, and in some cases the resolution is even better," Professor Keidar says. "We will continue to explore with this system how low we can get with dose and scan time."

The Discovery NM/CT 670 CZT was installed in early September 2015, and patients scanned thus far on this novel camera have been a mix of cardiac, lung, bone, renal, brain, thyroid, and parathyroid scans. Professor Keidar believes the properties of the CZT solid state detectors potentially enable additional capabilities that are not possible with a conventional camera.

"In some cases we noted that hardly detectable lesions were clearer on the CZT detector device*," Professor Keidar explains. One young athlete with foot pain underwent an exam in a conventional camera with normal results. In the CZT detector,

* In clinical practice, the use of Discovery NM/CT 670 CZT may improve lesions detectability depending on the clinical task, patient size, anatomical location and clinical practice. A consultation with a radiologist and a physicist should be made to determine the appropriate dose or scan time to obtain diagnostic image quality for the particular clinical task.

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> *Professor Zohar Keidar*

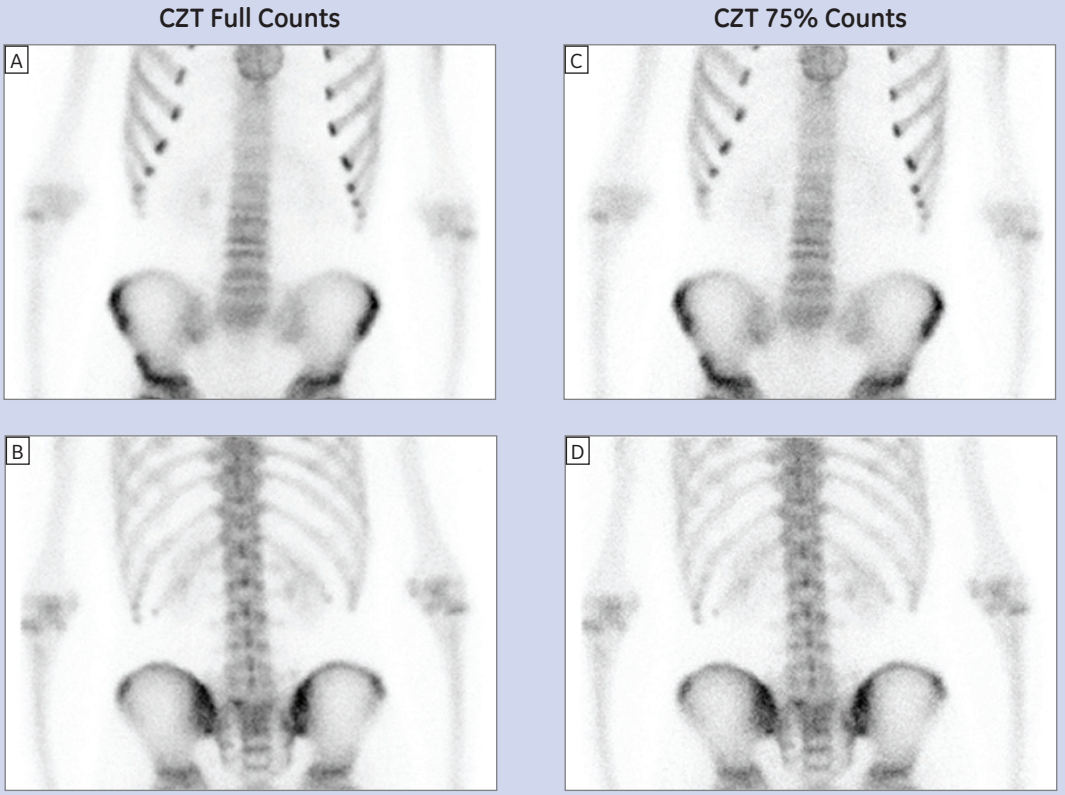

Figure 2. A 14-year-old patient with low back pain injected with 19.7 mCi Tc99 MDP, 5 min acquisition 3 hours post injection. (A, B) CZT images with 100% of the counts captured during the acquisition time; (C, D) CZT images are simulated at 75% of all counts with Lister tool.

Images courtesy of Mallinckrodt Institute of Radiology, St. Louis, MO.

Professor Keidar found a small lesion above the knee that may be causing the foot pain (Figure 1). There were additional examples similar to this where smaller lesions were more easily detected and better defined.* This includes higher differentiation of areas with varying intensity of activity in the CZT detector study in the thyroid gland of another patient compared to the conventional scan. "It may be possible to explore and understand the difference in activity within an organ, which is depicted much better on the Discovery NM/CT 670 CZT," Professor Keidar adds.

Based on the properties of the solid state detector, the energy resolution is improved from 9.5% of a traditional system to 6.3% with the CZT detector—and this has been supported by several phantom experiments conducted at Rambam Medical Center.

"The improved energy resolution will enable us to acquire two different isotopes at the same time, which is very interesting," he says. The improvements to spatial resolution may also imply better quantification‡ in studies performed with the device, and that could lead to research aiming at the development of new SPECT radiopharmaceuticals, he adds. "We are only at the beginning of exploring all these possibilities."

‡ In clinical practice, the use of Discovery NM/CT 670 CZT may improve quantification of lesions larger than 5.5mL, depending on the clinical task, patient size, anatomical location and clinical practice. A consultation with a radiologist and a physicist should be made to determine the appropriate dose or scan time to obtain the claimed quantification accuracy for the particular clinical task.

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> *Dr. Barry Siegel*

First Worldwide CZT Technology Upgrade

At Mallinckrodt Institute of Radiology (MIR), one of the premier radiological centers in the US, providing the best cost-effective patient care and seeking new knowledge to improve diagnosis and treatment of patients are central tenets of the facility's mission. In addition to this commitment to patient care, MIR is also dedicated to research, with a large fraction of MIR faculty and space devoted to research activities.

On April 4, 2016, MIR became the first institution worldwide to upgrade a Discovery NM/CT 670 Pro to a Discovery NM/CT 670 CZT. Upgrading an existing system made it more affordable to acquire this new technology, explains Barry A. Siegel, MD, Professor of Radiology, Senior Vice-chair and Division Director of Nuclear Medicine.

"The ability to retrofit an existing Discovery NM/CT 670 Pro is clearly useful," Dr. Siegel says. "Obviously, a field upgrade means we can get novel technology for less than it would cost to install a new camera." He adds that sometimes a new camera or system won't fit in an existing room without significant room preparation costs, such as shielding requirements, room expansions, electrical, HVAC, and floor loading.

"CZT is a significant change in nuclear medicine and we believe an improvement in existing technology," Dr. Siegel adds. However, Dr. Siegel believes that in addition to advancements in imaging technology, the industry also needs new software tools for analyzing imaging data and new radiopharmaceuticals to further expand nuclear medicine clinical applications. To this end, GE has so far introduced several new software tools in conjunction with the Discovery NM/CT 670 CZT, such as Q.Metrix, which enables the absolute quantification of a tracer uptake in a lesion or organ.

Demonstrating the value of CZT technology in general purpose nuclear medicine imaging will be a key focus of the research that Dr. Siegel and Richard Laforest, PhD, Associate Professor of Radiology and nuclear medicine physicist, will be pursuing.

With improved energy and spatial resolution on the Discovery NM/CT 670 CZT, Dr. Siegel will also examine workflow and how images are generated to further enhance image quality for improvements in lesion detectability*. "Also, using CZT we'll investigate what we can do with imaging and/or dose reduction while maintaining the image quality," Dr. Siegel explains.

Dose reduction and shorter exams have a clear benefit for patients, while also delivering new efficiencies and economic value to hospitals and health systems. For example, if shorter exam times translate to more patients being imaged on a scanner over the course of one day, then a facility could increase volume or reduce capital expenses and assets.

"In a typical hospital, that could mean getting by with four nuclear cameras instead of five, and that's clearly important from a capital and operating cost standpoint," Dr. Siegel says.

Dr. Laforest and Dr. Siegel will also look into the ability to change the way images are obtained with the Discovery NM/CT 670 CZT, for example, using the list mode acquisition and higher energy resolution to assess the potential benefits or tradeoffs by narrowing the energy window. Dr. Siegel says, "Will that clean up image quality beyond what we've seen so far? We'll see how much we manipulate our workflows and scan acquisitions to make the images better."

Another area of investigation is the use of quantification in nuclear medicine. Dr. Siegel says he believes in quantification, but the first step is to understand how to intelligently use measurements that weren't previously available. For example, he asks, what does an SPECT SUV of a bone scan mean clinically? If the SPECT SUV of a bone lesion, which tends to be very "hot," goes from 100 to 80, does that really qualify as a response? There is much research that needs to be done to know how to use absolute quantification in nuclear medicine and to understand what that data means in terms of the impact on patient treatment planning, Dr. Siegel explains.

Ideally, Dr. Siegel hopes that with the CZT technology he can achieve more precise and reliable quantification†. "Anything we can do to reduce inherent noise on the instrument side is a better starting place."

Dr. Laforest agrees and adds, "That improvement is a gain in spatial resolution that we may achieve with this camera to help improve the measurements of tumor size or other visible lesions."

Overall, both Dr. Laforest and Dr. Siegel are very excited about the potential of CZT and the impact their research data may have on clinical acceptance, utilization, and growth of nuclear medicine applications. ■