A Novel Cadmium-Zinc-Telluride SPECT System: A Challenge for Nuclear Cardiology in Japan

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Abstract

Cadmium-zinc-telluride (CZT) solid-state detectors have recently been introduced to myocardial single-photon emission computed tomography (SPECT) imaging. In this camera system, the conventional sodium iodide crystals have been replaced by CZT semiconductors, which directly convert radiation into electric signals. The energy resolution and spatial resolution have been significantly improved and the reduction of the acquisition time or radiotracer dose has been reported based on several studies. Two types of CZT camera system have been introduced in Japan: Discovery NM530c (GE Healthcare, Haifa, Israel) and D-SPECT (Spectrum Dynamics, Caesarea, Israel). With these new semiconductor systems, various study protocols for stress myocardial perfusion imaging (MPI) have been developed in Japanese institutions using different radioisotopes such as thallium-201 or technetium-99m radiotracers. In addition, not only quality of SPECT image but also diagnostic performance of this ultrafast camera system for Japanese patients has been evaluated.

Keywords: Cadmium-zinc-telluride camera, Coronary artery disease, Radiation dose reduction, Semiconductor detector, Single-photon emission computed tomography

See page 125, 131

Indeed, nuclear cardiologists are required to become accustomed to the new appearance of SPECT image derived from a CZT camera. In addition, they have to construct a new study protocol specialized to a CZT camera system, which should also be validated appropriately.

In this issue of Annals of Nuclear Cardiology, Hida reported application of the Discovery NM530c in his institution (7). At first, they prospectively compared MPI findings between a conventional Anger camera and CZT semiconductor systems in the same Japanese patients. With a 1-day stress/rest 99mTc-radiotracer imaging protocol, image acquisition for a standard gamma camera was 15 min each for stress and at rest while the scan time was 5 min for stress and 3 min for at rest using the CZT camera. Based on the observations showing strong correlations between the CZT camera and the standard camera for perfusion and function analyses, they reported that the novel CZT camera provides excellent image quality, which is
equivalent to standard myocardial SPECT, despite a short scan time of less than half of the standard data acquisition time (6).

In the next step, his group evaluated diagnostic performance of the Discovery NM530c, using either 201Tl or 99mTc-radiotracer, for coronary artery disease as assessed by fractional flow reserve (FFR) (7). With 201Tl, image acquisition was performed in the supine and prone positions after stress for 5 and 3 min, respectively, and in the supine position at rest for 10 min. To detect individual coronary stenosis, the respective sensitivity, specificity, and accuracy were 78% to 90%, 64% to 84%, and 72% to 81%, respectively (8). Furthermore, applying a low-dose stress/rest protocol (99mTc radiotracer 185/370 MBq), image acquisition was performed in the supine and prone positions after stress for 10 min and 6 min, respectively, and in the supine position at rest for 6 min. To detect individual coronary stenosis, the respective sensitivity, specificity, and accuracy were 76% to 87%, 75% to 92%, and 79% to 90%, respectively. They concluded that sensitivity, specificity, and accuracy were 78% to 87%, 75% to 92%, and 79% to 90%, respectively. They concluded that either with 201Tl or 99mTc radiotracer, in detecting a hemodynamically significant coronary stenosis as assessed by FFR. In particular, the estimated total radiation exposure with this low-dose 99mTc protocol of <5 mSv is noteworthy (9).

Aforementioned studies and others indicate that the merits of a novel CZT semiconductor system is particularly useful to radiation dose reduction although the use of 201Tl is still high in Japanese institutions (7, 9, 10). Since radiation exposure during stress MPI with 201Tl usually exceeds 10 mSv using the conventional Anger camera system, a wider use of the CZT camera system or switching radioisotope from 201Tl to 99mTc radiotracer is necessary to reduce radiation exposure during medical practice in Japan.

Concerning another type CZT camera system in Japan, new progress is also reported in this issue of Annals of Nuclear Cardiology by Nanasato et al (10). His group observed good to excellent image quality in >90% of patients studied by D-SPECT either with 201Tl or 99mTc radiotracer. Using 201Tl, furthermore, they compared left ventricular functional analysis between D-SPECT and Anger camera in the same patients, and showed good concordance of each functional index in the 2 camera systems (10). Since D-SPECT has a potential benefit to reduce radiation dose of 201Tl, which has been tightly regulated in Japan recently, the utilization of this new camera system may fulfill these requirements.

In addition, Makita et al. reported simultaneous acquisition of rest 99mTc-tetrofosmin and stress 201Tl dual-isotope MPI using D-SPECT (11). To detect individual coronary stenosis, the respective sensitivity, specificity, and accuracy were 74% to 85%, 81% to 93%, and 82% to 86%, respectively. Notably, total examination time of their protocol is 60 min (11). Although this ultra-short protocol was once attempted with Anger camera system using 201Tl for rest and 99mTc-sestamibi for stress, total radiation exposure of >25 mSv was the heel of Achilles. However, considerable reduction of the dose of radiotracer may be possible with the highly sensitive D-SPECT. In the near future, we expect to see revival of ultra-short MPI examination applying dual-isotope protocol.

Conclusions
While the innovative technology has enabled the development of the CZT semiconductor systems in the field of nuclear cardiology, the adaptation of Japanese researchers to this system is challenging. Nevertheless, recent scientific sessions and publications witness major advancements in this topic. In the future, new eras in nuclear cardiology applying this novel SPECT system will be opened, such as noninvasive measurements of coronary flow reserve and cardiac ganglion imaging to navigate catheter ablation for arrhythmias. To this end, efforts of Japanese colleagues in this field will continue.

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References