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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 In this camera system, the conventional sodium iodide crystals have been replaced by CZT semiconductors, which directly convert radiation into electric signals.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

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Cadmium-zinc-telluride (CZT) solid-state detectors have recently been introduced to myocardial single-photon emission computed tomography (SPECT) imaging (1-4). In this camera, the conventional sodium iodide crystals have been replaced by CZT semiconductors, which directly convert radiation into electric signals (4). The energy resolution and spatial resolution have been significantly improved and the reduction of the acquisition time or radiotracer dose has been reported compared to conventional Anger camera system based on several studies (5, 6). Until now, 2 types of the CZT camera system have been introduced in Japan: Discovery NM530c (GE Healthcare, Haifa, Israel) and D-SPECT (Spectrum Dynamics, Caesarea, Israel). While the development of this innovative technology is promising in nuclear cardiology practice, the adaptation of this novel modality is challenging to radiological technologists and physicians. 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 ^{99m}Tc-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

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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 ^{201}Tl or ^{99m}Tc-radiotracer, for coronary artery disease as assessed by fractional flow reserve (FFR) (7). With ^{201}Tl, 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 (^{99m}Tc 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 the CZT camera system demonstrated a good diagnostic yield, either with ^{201}Tl or ^{99m}Tc radiotracer, in detecting a hemodynamically significant coronary stenosis as assessed by FFR. In particular, the estimated total radiation exposure with this low-dose ^{99m}Tc 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 ^{201}Tl is still high in Japanese institutions (7, 9, 10). Since radiation exposure during stress MPI with ^{201}Tl usually exceeds 10 mSv using the conventional Anger camera system, a wider use of the CZT camera system or switching radioisotope from ^{201}Tl to ^{99m}Tc 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 ^{201}Tl or ^{99m}Tc radiotracer. Using ^{201}Tl, 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 ^{201}Tl, 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 ^{99m}Tc-tetrofosmin and stress ^{201}Tl 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 ^{201}Tl for rest and ^{99m}Tc-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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Conflicts of interest

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