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Original article

Diagnostic performance of a semiconductor gamma-camera system as studied by multicenter registry

Taishiro Chikamori (MD, PhD, FJCC)[a,*], Kenji Goto (MD, PhD)[b], Satoshi Hida (MD, PhD, FJCC)[a], Masao Miyagawa (MD, PhD)[c], Hayato Ishimura (RT)[c], Kenji Uchida (RT)[d], Takaya Fukuyama (MD, PhD, FJCC)[e], Teruhito Mochizuki (MD, PhD)[c], Akira Yamashina (MD, PhD, FJCC)[a]

[a] Department of Cardiology, Tokyo Medical University, Tokyo, Japan
[b] Department of Cardiology, Fukuyama Cardiovascular Hospital, Hiroshima, Japan
[c] Department of Radiology, Ehime University Graduate School of Medicine, Ehime, Japan
[d] Department of Radiology, Tokyo Medical University, Tokyo, Japan
[e] Department of Cardiology, Shin-Koga Hospital, Fukuoka, Japan

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ABSTRACT

Background: Despite the introduction of the novel cadmium–zinc–telluride (CZT) single-photon emission computed tomography (SPECT) in Japan; its diagnostic value in clinical practice remains largely unknown.

Methods: The Semiconductor SPECT Study group is a multicenter Japanese registry which registered 1000 patients to evaluate the diagnostic utility of the CZT camera system (Discovery NM530c; GE Healthcare, Haifa, Israel). The patients underwent stress myocardial SPECT and coronary angiography within a 3-month interval. A significant stenosis was defined as ≥75% diameter narrowing based on the American Heart Association classification.

Results: Technetium (^{99m}Tc) radiotracer (555–1110 MBq) was used in 71% and thallium-201 (^{201}Tl) (74–148 MBq) in 29%. The scan times with ^{99m}Tc-radiotracer were 5–10 min for stress and 3–10 min for rest, whereas those with ^{201}Tl were 5–9 min for stress and 8–10 min for rest. To detect individual coronary stenosis, the respective sensitivities, specificities, and accuracies were 74%, 85%, and 81% for left anterior descending coronary artery (LAD) stenosis, 76%, 89%, and 85% for left circumflex stenosis, and 72%, 86%, and 82% for right coronary artery stenosis. However, 66% sensitivity and 91% specificity for LAD stenosis were observed with ^{99m}Tc-radiotracer, whereas 88% sensitivity and 63% specificity were found with ^{201}Tl.

Conclusions: The novel CZT SPECT system facilitated a short scan time with reduced radiotracer dose, yielding an acceptable diagnostic performance for angiographical coronary artery disease, although the low sensitivity for LAD detection with ^{99m}Tc-radiotracer needs to be refined.

Introduction

The single-photon emission computed tomography (SPECT) system using gamma-ray detectors made of cadmium–zinc–telluride (CZT) has been introduced to myocardial perfusion imaging (MPI) [1–3]. In this CZT ultrafast SPECT system, the energy resolution and spatial resolution have been significantly improved, and a reduction of the acquisition time or radiotracer dose has been reported without loss of image quality [4–7]. Although these observations regarding this technology are promising [8], the diagnostic performance of the semiconductor detector has seldom been evaluated in Japan [9,10]. Nishiyama et al. reported the sensitivity and specificity of the CZT SPECT system using ^{99m}Tc-radiotracer only in 76 patients, whereas Tanaka et al. evaluated the diagnostic performance of this MPI system with ^{201}Tl as assessed using fractional flow reserve only in 95 patients [9,10]. Accordingly, investigators in 4 institutions, in which the CZT SPECT system (Discovery NM 530c; GE Healthcare, Haifa, Israel) has initially been

* Corresponding author at: Department of Cardiology, Tokyo Medical University, 6-7-1 Nishishinjuku, Shinjuku, Tokyo 160-0023, Japan. Tel.: +81 03 3342 6111; fax: +81 03 5381 6652.
E-mail address: chikamd@tokyo-med.ac.jp (T. Chikamori).

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introduced in Japan, have formed the Semiconductor SPECT Study (SSS) group. In the present study, we retrospectively collected a large number of registry data to assess the diagnostic performance of this ultrafast gamma-camera system based on conventional coronary angiography as a referential standard.

Methods

Subjects

The SSS group retrospectively registered 1000 patients with suspected or known coronary artery disease (CAD) who had undergone both stress SPECT with semiconductor detectors and coronary angiography within a 3-month interval between March 2011 and October 2014 from 4 institutions (Appendix). The clinical grounds for suspected or known CAD were based on clinical symptoms, coronary risk profiles, electrocardiographic findings, or past medical history. Patients requiring routine angiographic follow-up after successful percutaneous coronary intervention (PCI) were also included. The exclusion criteria were as follows: (1) age <20 years, (2) acute heart failure, (3) recent history of acute myocardial infarction or unstable angina within 1 month before the SPECT study, (4) history of coronary artery bypass grafting (5) advanced atrioventricular block or bronchial asthma, (6) hypertrophic or dilated cardiomyopathy, (7) severe valvular heart disease requiring surgical operation, (8) serious concomitant hepatic or renal disease, and (9) malignancy or any other acute illness requiring intensive treatment. There were 741 men and 259 women aged 69 ± 9 years (range 31–92 years). Hypertension was observed in 79% of the patients, diabetes mellitus in 39%, and dyslipidemia in 59% (Table 1). Written informed consent for invasive coronary angiography was obtained from all the participants. The study was approved by the Ethics Committee of Tokyo Medical University, as a central ethics committee, for a multicenter retrospective study including 3 other institutions (No. 2530). In addition, local ethics committees approved their participation in this study.

Table 1
Demographic data of 1000 patients.

Age (years)	69 ± 9 (range: 31–92)
Men/women	741/259 (74%/26%)
Height (cm)	161 ± 10 (range: 132–186)
Weight (kg)	63 ± 12 (range: 30–130)
Coronary risk factor	
Diabetes mellitus	393 (39%)
Hypertension	787 (79%)
Hypercholesterolemia	587 (59%)
Current smoker	313 (31%)
Family history of CAD	126 (13%)
Remote history of CAD	
PCI	506 (51%)
CABG	0 (0%)
Myocardial infarction	291 (29%)
Cardiac symptom	
Chest pain	242 (24%)
Dyspnea	94 (9%)
Palpitation	21 (2%)
Stress method for SPECT study	
Adenosine	430 (43%)
Adenosine + exercise	2 (0%)
ATP	415 (42%)
Exercise	153 (15%)
Radiotracer for SPECT study	
^{99m}Tc-radiotracer	711 (71%)
Tetrofosmin	661 (66%)
Sestamibi	50 (5%)
^{201}Tl	289 (29%)

ATP, adenosine triphosphate; CABG, coronary artery bypass grafting; CAD, coronary artery disease; PCI, percutaneous coronary intervention; SPECT, single-photon emission computed tomography.

Stress MPI

Using ^{99m}Tc-radiotracer (tetrofosmin or sestamibi) or ^{201}Tl, stress/rest myocardial SPECT imaging was performed by each institution according to its own protocols (Table 2). In brief, ^{99m}Tc-radiotracer of 555–1110 MBq or ^{201}Tl of 74–148 MBq was used. The stress protocol involved the administration of either exercise or vasodilator pharmacologic stress [11,12]. These stress methods

Table 2
Study protocol for ultrafast single-photon emission computed tomography system in each institution.

Fukuyama Cardiovascular Hospital
^{99m}Tc-tetrofosmin: standard dose (n = 349)
Stress 249–400 MBq: 5-min scan time in supine position → 3-min scan time in prone position
Rest 600–900 MBq: 5-min scan time in supine position → 3-min scan time in prone position
^{99m}Tc-tetrofosmin: low dose (n = 69)
Stress 123–222 MBq: 5-min scan time in supine position → 3-min scan time in prone position
Rest 198–606 MBq: 5-min scan time in supine position → 3-min scan time in prone position
^{201}Tl 111 MBq (n = 32), 148 MBq (n = 2)
Stress: 8-min scan time in supine position → 5-min scan time in prone position
Rest: 8-min scan time in supine position → 5-min scan time in prone position
Tokyo Medical University
^{99m}Tc-tetrofosmin: standard dose (n = 38), ^{99m}Tc-sestamibi: standard dose (n = 21)
Stress 370 MBq: 5-min scan time in supine position → 3-min scan time in prone position
Rest 740 MBq: 3-min scan time in supine position
^{99m}Tc-tetrofosmin: low dose (n = 149)
Stress 185 MBq: 10-min scan time in supine position → 3-min scan time in prone position
Rest 370 MBq: 6-min scan time in supine position
^{99m}Tc-sestamibi: low dose (n = 10)
Stress 185 MBq: 10-min scan time in supine position → 6-min scan time in prone position
Rest 370 MBq: 6-min scan time in supine position
^{201}Tl 74 MBq (n = 244), 111 MBq (n = 2)
Stress: 5-min scan time in supine position → 3-min scan time in prone position
Rest: 10-min scan time in supine position
Ehime University Graduate School of Medicine
^{99m}Tc-tetrofosmin: standard dose with long acquisition (n = 25)
Stress 296 MBq: 10-min scan time in supine position → 10-min scan time in prone position
Rest 740 MBq: 10-min scan time in supine position → 10-min scan time in prone position
^{99m}Tc-tetrofosmin: standard dose with short acquisition (n = 29)
Stress 296 MBq: 5-min scan time in supine position → 5-min scan time in prone position
Rest 740 MBq: 5-min scan time in supine position → 5-min scan time in prone position
^{99m}Tc-sestamibi: standard dose (n = 19)
Stress 370 MBq: 5-min scan time in supine position → 5-min scan time in prone position
Rest 740 MBq: 5-min scan time in supine position → 5-min scan time in prone position
^{99m}Tc-tetrofosmin: low dose (n = 2)
Stress 150–173 MBq: 5-min scan time in supine position → 5-min scan time in prone position
Rest 450–520 MBq: 5-min scan time in supine position → 5-min scan time in prone position
Shinkoga Hospital
^{201}Tl 74 MBq (n = 9)
Stress: 9-min scan time in supine position → 6-min scan time in prone position
Rest: 9-min scan time in supine position

All studies were performed with 1-day, stress–rest protocols.