REVIEW ARTICLE

True Opinions of Nuclear Cardiology Practitioners on Semiconductor SPECT Systems: A Multi-Center Survey-Based Review

Emi Tateishi, MD, PhD

Received: August 27, 2024/Accepted: September 11, 2024

Abstract

Nuclear cardiac imaging has advanced significantly with the development of semiconductor single photon emission computed tomography (SPECT) systems using cadmium zinc telluride detectors. These systems provide superior sensitivity and resolution compared to conventional anger-type SPECT systems, improving image quality and diagnostic accuracy. This study, conducted through a multi-center survey among nuclear cardiology practitioners, assessed changes in clinical practice following the implementation of semiconductor SPECT. Results showed shorter scan times, increased examination throughput, and reduced artifacts. However, challenges associated with semiconductor SPECT systems were also identified, including system-specific artifacts and cases that are difficult to image using these systems. These findings highlighted both the advantages and limitations of semiconductor SPECT in real-world clinical practice.

Keywords: Nuclear cardiology, Semiconductor SPECT, Technological challenges, User satisfaction
Ann Nucl Cardiol 2024; 10 (1): 51–54

Nuclear cardiac imaging has made remarkable progress since the development of single photon emission computed tomography (SPECT) systems equipped with cadmium zinc telluride (CdZnTe) semiconductor detectors. Semiconductor SPECT systems offer superior sensitivity and resolution compared to conventional anger-type SPECT systems due to their ability to directly convert gamma rays into digital signals (1, 2). Since the introduction of the first unit in Japan in 2012, the number of facilities equipped with Spectrum Dynamics' semiconductor SPECT systems has grown to more than 20 over the past decade. Numerous studies have demonstrated the high image quality of these systems and their utility in both qualitative and quantitative assessments of myocardial perfusion. However, few multicenter public surveys have been conducted to determine the impact of this high image quality and artifact reduction on real-world clinical practice and examination throughput provided by semiconductor SPECT systems, and to investigate user satisfaction with the results. This survey was conducted among members and participants of the "Semiconductor SPECT Research Group," composed of users of D-SPECT and VERITON (Spectrum Dynamics, Israel; Tokyo), in order to obtain genuine feedback from nuclear cardiology practitioners.

A paper-based questionnaire was conducted among nuclear cardiology practitioners at 19 facilities equipped with D-SPECT and/or VERITON. Responses were obtained from 13 physicians and 20 technologists. The questionnaire was completed anonymously, ensuring that the respondents could not be identified. Table 1 presents the clinical background of the respondents.

Initially, the imaging acquisition parameters for myocardial perfusion SPECT were investigated. D-SPECT, a dedicated camera for myocardial perfusion SPECT, allows the scan time to be optimized for acquiring the desired counts by setting a 3D region of interest (ROI) in the myocardium using pre-scan images. Among the respondents, 72.7% performed imaging using count-based acquisition, while 12.1% conducted imaging exclusively based on fixed-time acquisition. The most commonly used desired count setting was 1.2 megacounts (Figure 1). For fixed-time acquisition, various adjustments

DOI: 10.17996/anc.24-00009

Department of Radiology, National Cerebral and Cardiovascular Center, Osaka, Japan

Table 1 Clinical experience and imaging practices of respondents

Category	Response options	Number of respondents	Percentage
Years of clinical experience	<6 years	2	6.1%
	7-9 years	1	3.0%
	≥10 years	30	90.9%
Number of myocardial perfusion SPECT/day	1-3 exams	11	33.3%
	4-6 exams	16	48.5%
	≥7 exams	6	18.2%
Isotope usage of myocardial perfusion SPECT	^{201}Tl only	3	9.1%
	^{99m}Tc agents only	13	39.4%
	Both ^{201}Tl and ^{99m}Tc agents	17	51.5%
Experience in imaging beyond cardiac	Yes	8	24.2%
Experience with dynamic scanning	Yes	20	60.6%
Experience with dual-isotope imaging	Yes	20	60.6%
Regular use of anger-type SPECT system	Yes	27	81.8%

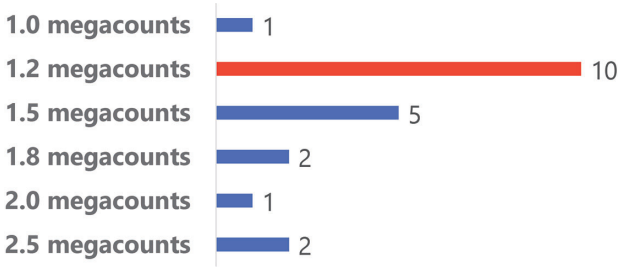

Figure 1 Count setting for myocardial data acquisition in semiconductor SPECT imaging.

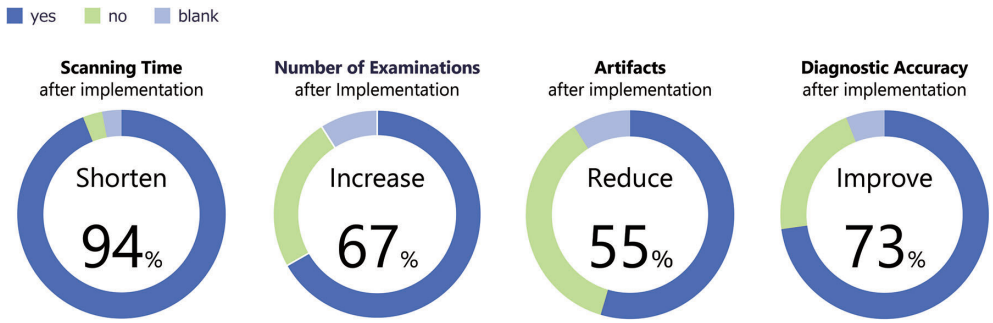

Figure 2 Real impressions of implementing semiconductor SPECT systems.

were made depending on the imaging conditions, such as:

- 15 minutes for stress imaging and 10 minutes for rest imaging when using ^{99m}Tc agents,
- Adjusting acquisition time based on patient body weight (e.g., 10 minutes for patients weighing 75 kg or less),
- Modifying acquisition time according to the types and doses of isotopes (e.g., 10 minutes for ^{201}Tl at 111 MBq).

The key finding in this survey was the perceived changes in clinical practice before and after the implementation of semiconductor SPECT systems (Figure 2). A majority of respondents (94%) experienced shorter scan time, and 67% noted an increase in examinations. Regarding the extent of this increase, some reported an additional 2–3 examinations per day, while others mentioned that the daily number of examinations had increased by 1.5 times. Furthermore, 55% of respondents noticed a reduction in artifacts, and 73% experienced improved diagnostic accuracy. The survey results demonstrated that the higher sensitivity and improved energy resolution of semiconductor SPECT systems significantly enhanced examination throughput and diagnostic accuracy in real clinical settings.

However, semiconductor SPECT systems present unique challenges and issues that can concern nuclear cardiology practitioners (Figure 3). Most users (88%) encountered some difficulties in scanning and imaging with semiconductor SPECT systems, and 57.6% encountered several challenging

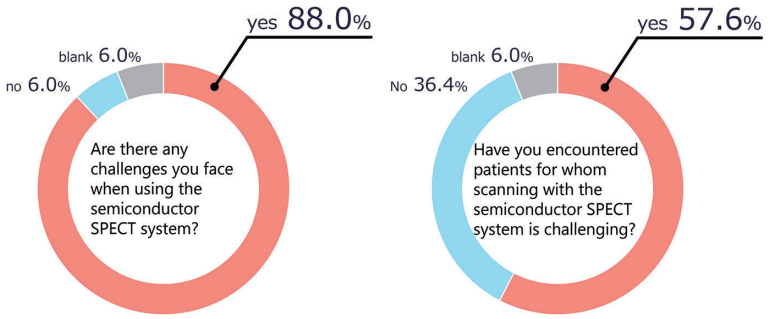

Figure 3 Challenges faced in using the semiconductor SPECT system.

Table 2 Challenges in imaging with semiconductor SPECT systems

Issues	Number of respondents	Percentages
Unable to perform planar imaging	24	72.7%
Positioning takes a long time	7	21.2%
Unable to perform imaging in the prone position (D-SPECT)	6	18.2%
Sensitive to motion	11	33.3%
Other Issues:	8	24.2%
Limited manufacturer support	3	9.1%
Limited flexibility in customizing imaging and reconstruction parameters	2	6.1%
Limited availability of appropriate normal databases	2	6.1%
System-specific artifacts in the apex (LAD distal territory)	1	3.0%
Not suitable for transferring wheelchair patients	1	3.0%

LAD, left anterior descending artery

Table 3 List of patients for whom imaging with D-SPECT is challenging

Category	Specific conditions/Issues
Cardiac conditions	Cardiomegaly (e.g., left ventricular dilatation, dilated cardiomyopathy)
	Extensive perfusion defects (especially in the apex)
	CD36 deficiency (no BMIPP uptake)
	Dextrocardia
Body types	Curved back (e.g., kyphosis)
	Severe obesity
	Children and infants
Patient-related issues	Difficulty in maintaining stillness
	Difficulty raising the left arm
	High extracardiac uptake
	Low pain tolerance

BMIPP, ^{123}I-β-methyl iodophenyl-pentadecanoic acid

cases when imaging with D-SPECT (Tables 2 and 3). While the introduction of semiconductor SPECT systems has improved image quality, users have noted the presence of system-specific artifacts and certain cardiac conditions that are unsuitable for D-SPECT.

Finally, 84.9% of nuclear cardiology practitioners were satisfied with the semiconductor SPECT system, while 6.0% were not. The remaining 9.1% were neutral in their responses. In addition, 54.5% expressed a desire to purchase a semiconductor SPECT system for the next equipment upgrade, and 33.3% were considering the purchase, depending on the outcome of negotiations concerning non-technical aspects, such as price and manufacturer warranties. Meanwhile, 10% indicated they would not mind switching to an Anger-type SPECT system.

The high image quality and resolution provided by the semiconductor SPECT system have improved the quality of examinations. Still, as highlighted in previous studies (3, 4),

Table 4 Pros and cons of implementing semiconductor SPECT systems

Aspects	Pros	Cons
Imaging quality	・High sensitivity and resolution ・Enhances image quality	・Inability to perform motion correction ・Inability to perform attenuation correction (D-SPECT)
Operational efficiency	・Shortens the scanning time ・Improves examination throughput	・Narrow field of view for scanning ・Complex procedures for dynamic scanning
Patient comfort	・Easier to maintain scanning position; no need to raise both arms, allows scanning in a sitting position	・Difficult for patients to get on and off the system
Radiation dose	・Reduces the dose of radioisotopes	・Low sensitivity for high-energy isotopes
Flexibility	・Capable of dynamic scanning for quantification of myocardial blood flow	・Limited flexibility in reconstruction for specific heart conditions and sizes ・Limited versatility
Clinical application	・Stabilizes image uniformity without being affected by body weight and shape ・Improves diagnostic accuracy	・Unable to perform planar imaging ・System-specific artifacts that hinder diagnosis ・Difficult to use for non-cardiac examinations
Technical maintenance	–	・High costs for maintenance and software upgrades

the results revealed challenges in achieving optimal imaging with the semiconductor SPECT system in real-world clinical practice. The results of this multi-center survey are insightful, and they could contribute to further research on semiconductor SPECT and advancing nuclear cardiology.

Acknowledgments

I would like to express my sincere gratitude to the organizers, facilitators, and participants of the "Semiconductor SPECT Research Group" for their invaluable assistance in conducting this survey. Their cooperation and support have been instrumental in obtaining these insights, and I sincerely appreciate their contributions to this study.

Sources of funding

None.

Conflicts of interest

None.

Reprint requests and correspondence:
Emi Tateishi, MD, PhD
Department of Radiology, National Cerebral and Cardiovascular Center, 6-1 Kishibe-Shinmachi, Suita, Osaka 564-8565, Japan
E-mail: emitat@ncvc.go.jp

References

1. Niimi T, Nanasato M, Sugimoto M, Maeda H. Evaluation of cadmium-zinc-telluride detector-based single-photon emission computed tomography for nuclear cardiology: A comparison with conventional anger single-photon emission computed tomography. Nucl Med Mol Imaging 2017; 51: 331–7.
2. Nudi F, Iskandrian AE, Schillaci O, Peruzzi M, Frati G, Biondi-Zoccai G. Diagnostic accuracy of myocardial perfusion imaging with CZT technology: Systemic review and meta-analysis of comparison with invasive coronary angiography. JACC Cardiovasc Imaging 2017; 10: 787–94.
3. Allie R, Hutton BF, Prvulovich E, Bomanji J, Michopoulou S, Ben-Haim S. Pitfalls and artifacts using the D-SPECT dedicated cardiac camera. J Nucl Cardiol 2016; 23: 301–10.
4. Mansour N, Nekolla SG, Reyes E, et al. Multi-center study of inter-rater reproducibility, image quality, and diagnostic accuracy of CZT versus conventional SPECT myocardial perfusion imaging. J Nucl Cardiol 2023; 30: 528–39.