tomographic angiography to predict future acute coronary syndrome. J Am Coll Cardiol 2013;61:2296–305.

4. Hadamitzky M, Taubert S, Deseive S, et al. Prognostic value of coronary computed tomography angiography during 5 years of follow-up in patients with suspected coronary artery disease. Eur Heart J 2013; 34:3277–85.

5. Motoyama S, Ito H, Sarai M, et al. Plaque characterization by coronary computed tomography angiography and the likelihood of acute coronary events in mid-term follow-up. J Am Coll Cardiol 2015;66:337–46.

Reduction of SPECT MPI Radiation Dose Using Contemporary Protocols and Technology

The nuclear cardiology field embarked several years ago on an aggressive effort to reduce radiation exposure for single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) (1). Several reports suggest substantial lag in the adoption of radiation-sparing approaches (2,3). However, some laboratories have made considerable progress and the impact of these efforts is not well recognized.

Data from SPECT MPI studies performed at the 4 Saint Luke's Mid America Heart Institute nuclear cardiology laboratories from January 2009 to September 2016 (n = 18,162) were reviewed. Effective dose (*E*) was calculated from the recorded actual administered dose of Tl-201, Tc-99m sestamibi, and Tc-99m tetrofosmin, using standard conversion factors (4). The department quality control committee reviewed images regularly.

In 2009, all studies were on large field of view (FOV) Anger cameras. By early 2011, Tl-201 protocols were completely eliminated. Two cadmium-zinc-telluride cameras (Spectrum Dynamics Medical, Inc., Sarasota, Florida) and 2 small FOV Anger cameras equipped with advanced post-processing software (Cardio MD, ASTONISH, Philips Medical, Bothell, Washington) replaced older generation large FOV cameras between Spring 2010 and Fall 2012. Protocols designed to minimize radiotracer (especially low-dose stress-first/stress-only protocols) were used over that time, and low-dose stress-first became a default protocol for most patients except those with prior infarction or known cardiomyopathy. Also, large FOV cameras (less appropriate for low-dose protocols) became used almost exclusively for morbidly obese patients.

After the elimination of Tl-201 and before the widespread usage of new camera technologies, mean effective dose *E* decreased from 17.9 in 2009 to a mean of 12.1 mSv. Since Fall 2012, the mean *E* of the 4,035 studies conducted on small FOV cameras with advanced post-processing software was 5.6 mSv (mean body mass index [BMI], 29.5 kg/m^2), and in the 5,592 studies performed on cadmium-zinc-telluride cameras, mean *E* was 2.8 mSv (mean BMI, 29.3 kg/m^2). For the 1,609 patients imaged on large FOV camera since 2014, mean BMI was much larger (45.8 kg/m^2), as was mean *E* (14.5 mSv). Since Fall 2012, more than 69% of MPI studies were performed using low-dose, stress-only imaging.

Overall *E* decreased dramatically over the course of the study from a mean of 17.9 mSv in 2009 to 7.2 mSv in 2016; median *E* decreased from 10.3 mSv in 2009 to 2.5 mSv in 2016, representing 60% and 76% reductions, respectively (**Figure 1**). During years 2014 to 2016, the mean dose of radiotracer rose slightly. Mean BMI also rose during this time, from 31.9 to 33.1 kg/m^2. This study demonstrates the compelling impact of a comprehensive radiation-reduction strategy in a large nuclear cardiology laboratory network. The study includes consecutive patients tested from 2009 to 2016 (over 18,000 SPECT MPI tests) and spans an era of significant advances in nuclear cardiology and changes in practice patterns.

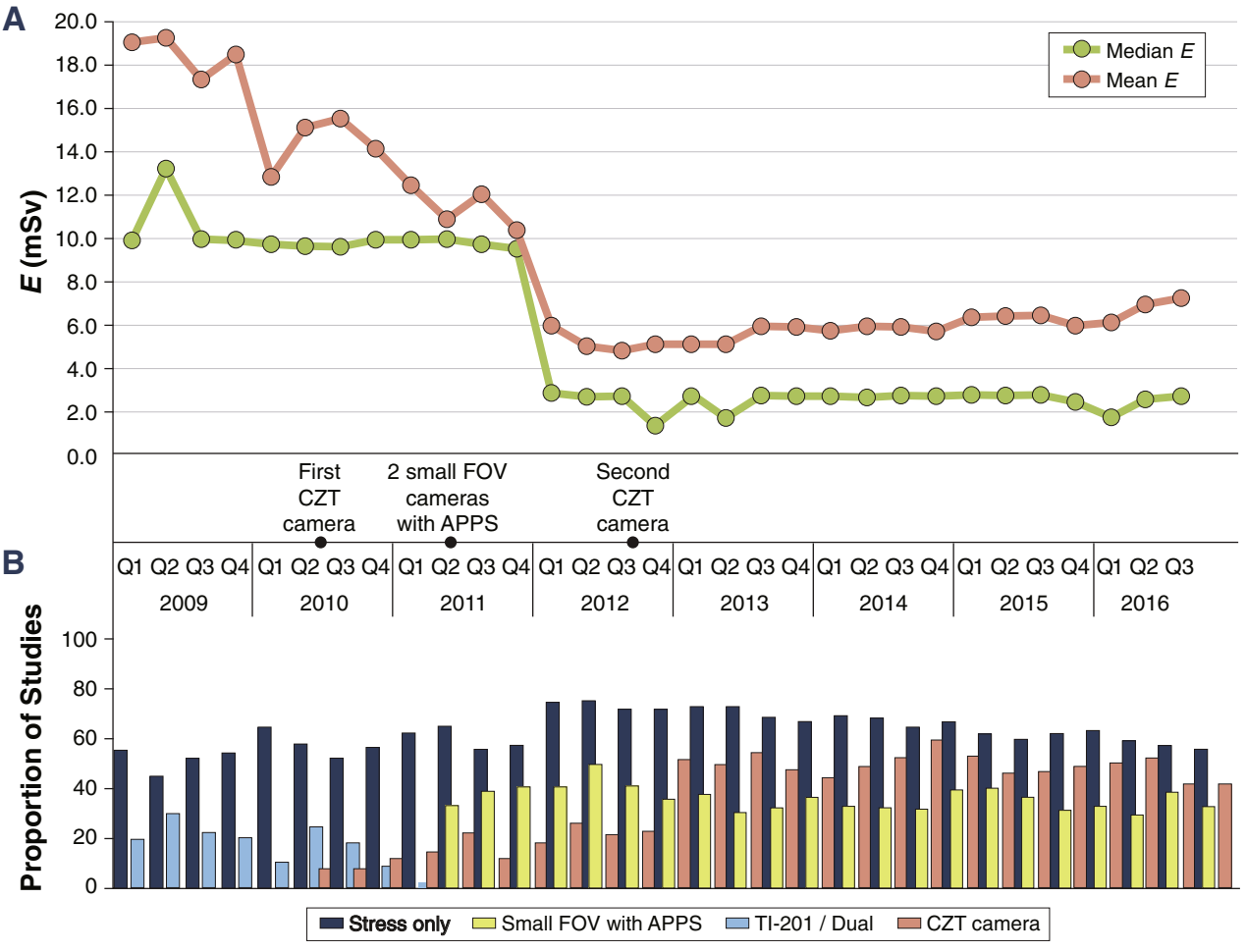
The cumulative result has been a striking reduction in radiation dose to the patient. Mean *E* has decreased about 60%, whereas the median dose has decreased by 76%, and is now <3 mSv. Most patients the last 5 years received <3 mSv, one-third of median target dose set by the American Society of Nuclear Cardiology (1). In contrast, most patients (58%) in our laboratories in 2009 received >9 mSv. These results were achieved despite a high prevalence of obesity.

Our results show much greater reduction in radiation than the overall data from the Intersocietal Accreditation Commission and from surveys conducted by the INCAPS investigators (2,3). In the Intersocietal Accreditation Commission study of U.S. laboratories, the mean effective dose was 14.9 mSv, whereas in the INCAPS study of 308 nuclear laboratories in 65 countries, the median effective dose was 10.0 mSv (2,3).

Interventions that drove the reduction in radiation dosage include elimination of Tl-201 and dual isotope imaging protocols; and implementation of lower-dose protocols, especially low-dose, stress-only imaging, facilitated by newer cadmium-zinc-telluride camera systems and the use of small FOV Anger cameras with advanced reconstruction software.

The data presented here demonstrate that adoption of widely available hardware and software options, and implementation of stress-first/stress-only protocols are practical in real-world daily practice and can result in very low radiation exposures for SPECT MPI.

FIGURE 1 Effective Dose for SPECT MPI 2009 to 2016, Mid America Heart Institute Nuclear Cardiology Laboratories



(A) Effective dose (*E*) for SPECT MPI tests performed at the Mid America Heart Institute. **(B)** Proportion of studies undergoing selected cameras and protocols. APPS = advanced post-processing software; CZT = cadmium-zinc-telluride; FOV = field of view; MPI = myocardial perfusion imaging; SPECT = single-photon emission computed tomography.

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REFERENCES

1. Cerqueira MD, Allman KC, Ficaro EP, et al. Recommendations for reducing radiation exposure in myocardial perfusion imaging. J Nucl Cardiol 2010;17:709–18.

2. Jerome SD, Tilkemeier PL, Farrell MB, Shaw LJ. Nationwide laboratory adherence to myocardial perfusion imaging radiation dose reduction practices: a report from the Intersocietal Accreditation Commission Data Repository. J Am Coll Cardiol Img 2015;10:1170–6.

3. Einstein AJ, Pascual TN, Mercuri M, et al. Current worldwide nuclear cardiology practices and radiation exposure: results from the 65 country IAEA Nuclear Cardiology Protocols Cross-Sectional Study (INCAPS). Eur Heart J 2015;36:1689–96.

4. Eckerman K, Harrison J, Menzel H-G, Clement CH. Compendium of dose coefficients based on ICRP Publication 60: ICRP Publication 119. Ann ICRP 2012;41 Suppl 1:1–130.