those in the community. Third, many respondents reported waiting until a patient's death was imminent before discussing EOL issues.

These findings are important. They provide a better sense of hematologic oncologists' awareness of gaps in the quality of EOL care, confirming that hematologic oncologists generally do not have their "heads in the sand" about how they tend to practice. Even more importantly, these findings suggest that hematologic oncologists are uncertain about how to actually change the status quo of EOL issues, thereby highlighting a practice gap in need of an intervention. As a practicing hematologic oncologist and a palliative care physician, I believe that the field of hematology should look to specialty palliative care for the answer to this need.

A robust literature demonstrates that early, concurrent palliative care yields many benefits for patients and caregivers facing advanced cancer, including improved prognostic awareness, better quality of life, and less depression.[7] It is increasingly clear that the mechanism of action of palliative care has much to do with adding a uniquely skilled expert to further support the patient and family beyond the support provided through standard cancer care. Although some oncologists worry that this amounts to an abrogation of their personal responsibility to address important issues with their patients, data show that patients prefer to talk about different issues with their oncologist than with their palliative care specialist.[8] Together, everyone accomplishes more, and each team member complements the others. Unfortunately, landmark studies of early palliative care have largely excluded patients with hematologic cancers.

If palliative care is the answer to the problems in the quality of EOL care in hematologic cancers, researchers must study and better understand the unique needs of patients with hematologic cancers and their oncologists. For example, comparatively little is known about the symptom burden and palliative care needs of patients with hematologic cancers, which are a remarkably heterogeneous collection of diseases. Similarly, hematologic oncologists and palliative care specialsts together must better understand the unique needs of the specialists who treat these patients as we develop models of concurrent palliative care. Building bridges with colleagues in palliative care is the next step toward reducing gaps in the quality of EOL care of patients with hematologic cancers, and will enable cancer centers, cancer care teams, and specialists to better serve their patients and their patients' families together as a unified team.

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Comparison of Radiation Doses and Best-Practice Use for Myocardial Perfusion Imaging in US and Non-US Laboratories: Findings From the IAEA (International Atomic Energy Agency) Nuclear Cardiology Protocols Study

Myocardial perfusion imaging (MPI) is integral to the diagnosis and management of known or suspected coronary artery disease[1,2] and is therefore performed on millions of US patients each year. However, the associated exposure to ionizing radiation has raised concerns about potential radiation-related health effects. The recent cross-sectional study of MPI practice conducted by the International Atomic Energy Agency (IAEA) demonstrated significant variations in radiation doses, and in the use of best practices that can help to reduce dose, among laboratories worldwide.[3] Although survey data have described self-reported US use of different MPI protocols and some dose-reduction methods,[4] no previous study, to our knowledge, has characterized actual US MPI radiation doses as well as use of best practices. We compared actual MPI practice and radiation doses in US and non-US laboratories and identified opportunities to improve radiation doses in the United States.

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Methods | Data were collected as part of the IAEA Nuclear Cardiology Protocols Study (INCAPS).[3] The INCAPS data included patient demographics, estimated effective radiation dose for each patient, and laboratory best practices that affect radiation dose, from 308 nuclear cardiology laboratories in 65 countries, including 50 US laboratories in 22 states encompassing all regions of the country. Each laboratory provided data on a consecutive series of patients undergoing MPI during a 1-week period from March 18 to April 22, 2013, yielding 7911 patients (including 1902 US patients). The study was approved by the institutional review board of Columbia University. Because no individually identifiable

Table 1. Patient Demographic and Clinical Characteristics

Characteristic	US Patients (n = 1902)	Non-US Patients (n = 6009)	*P* Value[a]
Female, No. (%)	822 (43.2)	2432 (40.5)	.03
Age, mean (SD), y	66 (12)	64 (12)	<.001
Stress-only imaging, No. (%)	54 (2.8)	951 (15.8)	<.001
SPECT protocol, No. (%)			
Single-day	1503 (79.0)	3966 (66.0)	<.001
Multiple-day	94 (4.9)	1877 (31.2)	<.001
PET	305 (16.0)	166 (2.8)	<.001
Effective dose of radiation			
Median (IQR), mSv	11.6 (9.2-13.1)	9.7 (6.4-12.3)	<.001
Mean (SD), mSv	10.9 (4.4)	9.7 (4.5)	<.001
≤9 mSv, No. (%)	465 (24.4)	2600 (43.3)	<.001
SPECT studies only, mSv			
Median (IQR)	12.1 (11.0-13.3)	9.8 (6.8-12.4)	<.001
Mean (SD)	12.3 (3.4)	9.8 (4.4)	<.001
PET studies only, mSv			
Median (IQR)	3.7 (3.3-4.0)	2.5 (1.8-3.5)	<.001
Mean (SD)	3.7 (0.7)	3.7 (3.9)	.83

Abbreviations: IQR, interquartile range; PET, positron emission tomography; SPECT, single-photon emission tomography.

[a] Calculated using Kruskal-Wallis tests and analysis of variance for median and mean radiation doses and quality index scores and using χ^2 tests for best practices and proportion with a median radiation dose of no more than 9 mSv. $P < .05$ was considered significant.

Table 2. Laboratory Characteristics

Characteristic	US Laboratories (n = 50)	Non-US Laboratories (n = 258)	*P* Value[a]
No. of patients per laboratory			
Median (IQR)	31 (14-46)	14 (7-30)	<.001
Mean (SD)	38 (39)	23 (30)	.002
Quality index score[b]			
≥6, No. (%)	15 (30.0)	127 (49.2)	.01
Median (IQR)	5 (4-6)	5 (5-6)	<.001
Mean (SD)	4.6 (1.2)	5.6 (1.2)	<.001
With median radiation dose ≤9 mSv, No. (%)	7 (14.0)	84 (32.6)	.008
Best practices, No. (%)			
Avoid thallium stress imaging in patients aged ≤70 y	50 (100)	232 (89.9)	.01
Avoid dual-isotope stress imaging in patients aged ≤70 y	48 (96.0)	250 (96.9)	.67
Avoid too much technetium Tc 99m[c]	28 (56.0)	235 (91.1)	<.001
Avoid too much thallium[d]	50 (100)	256 (99.2)	.10
Perform stress-only imaging[e]	9 (18.0)	84 (32.6)	.04
Use camera-based dose reduction strategies[f]	28 (56.0)	178 (69.0)	.10
Use weight-based dosing for technetium Tc 99m[g]	8 (16.0)	80 (31.0)	.04
Avoid shine-through artifact[h]	8 (16.0)	128 (49.6)	<.001

Abbreviation: IQR, interquartile range.

[a] Calculated using Kruskal-Wallis tests and analysis of variance for median and mean radiation doses and quality index scores and using χ^2 tests for best practices and proportion with a median radiation dose of no more than 9 mSv. $P < .05$ was considered significant.

[b] Defined as the number of best practices followed of a possible 8.

[c] Indicates no more than 36 mCi for any single injection of technetium Tc 99m, and mean effective dose of less than 15 mSv for all studies using technetium Tc 99m only.

[d] Indicates no more than 3.5 mCi of thallium at stress imaging.

[e] At least 1 study used stress imaging only.

[f] At least 1 study used attenuation correction, multiple-position imaging, or advanced software or hardware.

[g] We found a statistically significant positive correlation between patient weight and millicuries of technetium Tc 99m.

[h] In single-day technetium Tc 99m studies, activity of second injection was at least 3 times that of the first injection.

health information was collected, the board declared it exempt from the requirements of US federal regulations for the protection of human subjects.

An IAEA expert panel defined a priori 8 laboratory best practices affecting radiation doses.[3] These included (1) avoiding thallium stress testing in patients 70 years or younger, because thallium has a long half-life (3 days) and exposes patients to more radiation than technetium Tc 99m–based radiopharmaceuticals used for MPI; (2) avoiding use of a dual-isotope (thallium and technetium Tc 99m) protocol in nonel-

derly patients; (3) avoiding too much technetium Tc 99m; (4) avoiding too much thallium; (5) performing stress-only imaging in some patient(s), rather than requiring every patient to have rest imaging and its attendant radiation dose even for studies with completely normal myocardial perfusion at stress; (6) using camera-based dose-reduction strategies, such as advanced hardware or software, or imaging in the supine and prone positions, which can clear false-positive perfusion defects owing to soft-tissue attenuation and thereby facilitate stress-only imaging; (7) applying weight-based dosing for technetium Tc 99m so that lighter patients receive less isotope; and (8) avoiding dosing that leads to residual counts from the first injection interfering with interpretation of the second scan, known as a shine-through artifact. Each laboratory was assigned a quality index score, defined as the number of best practices followed. Methodologic details regarding data collection, dose estimation, and best-practice definitions are presented elsewhere.[3] The US laboratories included responded to an invitation distributed to contacts from lists provided by the IAEA, American Society of Nuclear Cardiology, and Intersocietal Accreditation Commission.

Median and mean patient and laboratory radiation doses and laboratory quality index scores were compared between US and non-US laboratories using Kruskal-Wallis tests and analysis of variance. The proportion of laboratories adhering to each best practice, 6 or more best practices, and a median radiation dose of no greater than 9 mSv (a threshold specified in professional society recommendations[5]) were compared using χ^2 tests. All analyses were performed with STATA/SE (version 13.1; StataCorp).

Results | Compared with non-US patients, US patients undergoing MPI were older and included a greater proportion of women. The US radiation dose was higher (median, 11.6 vs 9.7 mSv; mean, 10.9 vs 9.7 mSv; $P < .001$ for both), and fewer US patients had a dose of 9 mSv or less (24.4% vs 43.3%; $P < .001$) (**Table 1**). The US patients were 7.6 times (95% CI, 6.1-9.4) more likely to undergo single-photon emission computed tomographic MPI using a 1-day protocol and 6.7 times (95% CI, 5.5-8.3) more likely to undergo positron emission tomography ($P < .001$ for both).

The median radiation dose ranged from 3.5 to 24.5 mSv among US laboratories. Only 7 of 50 US laboratories (14.0%) achieved a median dose of 9 mSv or less compared with 84 of 258 non-US laboratories (32.6%). Best-practice adherence was lower among US laboratories (**Table 2**), as reflected in a lower mean quality index (4.6 vs 5.6; $P < .001$) and the smaller proportion of laboratories with a quality index of 6 or better (15 of 50 [30.0%] vs 127 of 258 [49.2%]; $P = .01$). The US laboratories outperformed non-US laboratories in avoiding thallium stress imaging in patients younger than 70 years but underperformed in 4 of the other 7 practices.

Discussion | We observed a 20% higher radiation dose to the typical patient undergoing MPI in a US laboratory compared with a patient in a non-US laboratory. This difference results in part from lower adherence to radiation-dose best practices among US laboratories. Practices such as weight-based dosing (16.0% vs 31.0%), judicious technetium Tc 99m use (56.0% vs 91.1%), and implementation of stress-only protocols in some patients (18.0% vs 32.6%) were adopted significantly less often in US facilities (Table 2). The higher radiation doses and less frequent use of these important best practices that we observed are coupled with markedly more frequent US use of MPI (2500 MPI studies per 100 000 population in a previous IAEA study[6]) than in other developed countries (eg, 1200, 364, 315, and 120 MPI studies per 100 000 population in Canada, Australia, Japan, and the United Kingdom, respectively[6]). Improvements in adherence to these best practices offer potential opportunities, that do not require any specific technology, to reduce the radiation burden of MPI in the United States through greater attention to patient-centered imaging.

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Estimating the Reduction in the Radiation Burden From Nuclear Cardiology Through Use of Stress-Only Imaging in the United States and Worldwide

Myocardial perfusion imaging (MPI) is invaluable in diagnosing and managing coronary artery disease; however, it accounts for approximately 10% of the radiation burden to the US population.[1] Use of a "stress-only" imaging protocol, whereby stress imaging is performed first and subsequent rest imaging is omitted when stress images are determined to be normal, has been shown to reduce radiation burden without compromising patient safety.[2] Although single-center data support that a 60% reduction in radiation dose may be realized with the use of stress-only imaging,[2] data from a US survey suggest that stress-only protocols are infrequently performed.[3] We sought to estimate current rates of stress-only imaging in the United States and worldwide, as well as the potential effect of changes in this rate on the radiation burden to the US population.

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Methods | Data on MPI protocols used in clinical practice were collected as part of the International Atomic Energy Agency Nuclear Cardiology Protocols Study (INCAPS),[4] a cross-sectional registry of 7911 patients undergoing MPI in 308 laboratories in 65 countries. Laboratories provided data, including protocols, radiopharmaceuticals, and administered activities, for all studies performed during a 1-week period between March 18 and April 22, 2013. Data analysis was performed from August 18, 2014, to July 16, 2015. We excluded from analysis 1196 patients (339 from the United States) who underwent single-photon emission computed tomographic imaging reflecting myocardial perfusion at rest only, with no stress testing performed; a protocol involving thallium 201, for which information regarding perfusion at rest or myocardial viability may be of interest in addition to findings from stress testing; or positron emis-