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Multiple opportunities to reduce radiation dose from myocardial perfusion imaging

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Radiation exposure to patients and practitioners from myocardial perfusion imaging (MPI) has grown markedly over the past three decades. Worldwide, 15–20 million MPI procedures are now performed annually. This growth is in a part a reflection of the dissemination of a clinically useful technology, as MPI enables the evaluation and characterization of coronary and myocardial disease in a host of diagnostic scenarios. This, however, has led to a situation where in some practice settings, MPI is the single largest contributor to medical radiation burden[1], and published estimates suggest that this burden may be causal of thousands of cancers each year.[2] The appropriate response for practitioners is to redouble our efforts to implement the fundamental principles of radiological protection: justification and optimization.[3] Justification, in practice, entails making sure each and every MPI exam performed is the right test for the right patient at the right time. Optimization, encompassing the principle of ALARA (As Low As Reasonably Achievable), entails making sure that each test is performed in the right manner, ensuring that we obtain good quality diagnostic information while minimizing radiation dose.

But is it practicable to appreciably reduce radiation dose in real-world clinical practice? In this issue of the *European Journal of Nuclear Medicine and Molecular Imaging*, Marcassa and colleagues report changes in administered activity (MBq) and its associated radiation effective dose (mSv) in a cohort of over 9000 patients undergoing MPI over the past decade at a single center in Italy.[4] All patients received two-day, stress-rest protocols with Tc-99m sestamibi. Initially, a fixed activity was specified for each radiopharmaceutical administration with three possible activities, based on weight. This was the protocol suggested by the Italian Association of Nuclear Medicine. Subsequently, the authors' laboratory changed to a protocol with patient-specific weight-based dosing at 8 MBq/kg up to a maximum of 1110 MBq. During the final period, the laboratory began using a new image reconstruction software product which incorporates iterative reconstruction, resolution recovery, and noise reduction algorithms[5], which enabled them to halve sestamibi administered activity to 4 MBq/kg. Marcassa et al found that the total actual administered activity, estimated effective dose to patients, and badge-derived physician doses all significantly decreased with each change in protocol.

Marcassa et al's study is not without its limitations. The inclusion of data on image quality or diagnostic accuracy during the three study periods would have greatly strengthened the case that the dose-reduction measures did not deleteriously effect the diagnostic information provided by these MPI studies. Cancer risk estimates were performed using a very general risk coefficient developed for the whole population.[3] Use of this coefficient fails to reflect

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the implications of MPI patient demographics on cancer risk—in comparison to the general worldwide population, the MPI patient population is older, has a higher percentage of men, and has shorter life expectancy given its higher prevalence of coronary disease. Each of these factors decreases risk of radiation-associated cancer[6], suggesting that Marcassa and colleagues' cancer risk estimates are likely to be over-estimates.

Nevertheless, the study by Marcassa and colleagues teaches three important lessons. Firstly, it demonstrates that multiple radiation dose-reduction techniques can be implemented in tandem to achieve a marked reduction in dose while providing a clinically useful MPI service. In fact, there are several dose-reduction approaches available at our disposal (Table 1). These include weight-based determination of administered activity and use of new image reconstruction software, the two approaches employed in Marcassa's laboratory. Using these two approaches, the authors report great improvements in radiation dosimetry from MPI, with a 58% reduction in average effective dose observed over the course of this study.

Despite this marked radiation dose reduction, one could contend that the authors haven't yet taken advantage of every opportunity to decrease radiation exposure. In particular, all patients received both stress and rest imaging using a "dual-day stress-rest" protocol.[4] By virtue of performing stress imaging on the first day, this should obviate the need for rest imaging in the many patients for whom physician review of stress images prior to rest imaging evidences normal perfusion, left ventricular function, and wall motion.[7] For example, in a series of 27,540 consecutive MPI patients over an 8 year period, of the 16,854 (61%) patients with normal myocardial perfusion, Chang et al were able to avoid rest imaging in 48% of cases.[8] Numerous studies have demonstrated excellent prognosis with a normal stress-only study[9–11], and thus across-the-board performance of rest imaging reflects imperfect implementation of the principle of optimization.

Another significant take-away point raised by this study is the reduction in physicians' doses that accompanied the reduction in patients' doses. By paying attention to reducing radiation exposure to our patients, in general we'll receive less radiation exposure ourselves. A third important lesson is that some national guidelines for MPI may need to be updated. Marcassa et al initially protocoled studies based on diagnostic reference levels suggested by the Italian Association of Nuclear Medicine, but later recognized that they could improve in terms of radiation dosimetry. The 2005 EANM/ESC procedural guidelines for myocardial perfusion imaging in nuclear cardiology[12] demonstrates considerable variability between countries in recommended administered activities for nuclear cardiology protocols. While the development and application of national or regional imaging practice guidelines is laudatory, to reflect differences between populations in the spectra of patient habitus, disease prevalence, test utilization, and technology, Marcassa et al have shown us the importance of updating guidelines, reference levels, and practice protocols to reflect the developing evidence base and our enhanced appreciation for the importance of radiation protection.

The situation in which we find ourselves, with MPI the single largest contributor to medical radiation burden in some locales, need not be a permanent one. By taking concrete steps to decrease this burden, we have the potential to dramatically decrease population radiation doses from MPI and their associated cancer risks. Marcassa and colleagues' continuing efforts to reduce, and reduce again, the radiation exposure to patients in their laboratory should serve as a model for each of us.

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Table 1

Dose Reduction Opportunities in Myocardial Perfusion Imaging

Radiopharmaceutical Selection
Tc-99m-based tracers lower patient dose compared to Tl-201
PET tracers (N-13 ammonia, Rb-82) lower patient dose compared to SPECT tracers
Protocol Selection, e.g. Stress-First/Stress-Only Imaging
Administered Activities Chosen
Weight-based administered activity
Post-Administration
Hydration and early micturition can reduce dose to genitourinary system
Technological Advancements
Software
Iterative reconstruction
Resolution recovery
Noise reduction
Hardware
Solid-state camera