Multiple opportunities to reduce radiation dose from myocardial perfusion imaging

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Exposure of patients and practitioners to radiation 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 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 the cause of thousands of cancers each year [2]. The appropriate response from 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 examination 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 a recent issue of the *European Journal of Nuclear Medicine and Molecular Imaging*, Marcassa and colleagues reported changes in administered

activity (megabecquerels) and its associated radiation effective dose (millisieverts) in a cohort of over 9,000 patients undergoing MPI over the past decade at a single center in Italy [4]. All patients received 2-day, stress–rest protocols with ^{99m}Tc -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 1,110 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 the administered sestamibi activity to 4 MBq/kg. Marcassa et al. found that the total actual administered activity, the estimated effective dose to patients, and badge-derived physician doses all significantly decreased with each change in protocol.

The study of Marcassa et al. 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 adversely affect 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]. Their use of this coefficient fails to reflect the implications of MPI patient demographics on cancer risk—in comparison to the general worldwide population, the MPI patient population was older, had a higher percentage of men, and had shorter life expectancy given its higher prevalence of coronary disease. Each of these factors decreases the risk of radiation-associated cancer [6], suggesting that the cancer risk

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Table 1 Dose reduction opportunities in MPI

Dose-reduction technique	Dose-reduction potential
Radiopharmaceutical selection	^{99m}Tc -based tracers result in lower patient dose than ^{201}Tl PET tracers (^{13}N ammonia, ^{82}Rb) result in lower patient dose than SPECT tracers
Protocol selection, e.g., stress-first/stress-only imaging	
Administered activities chosen	Weight-based administered activity
After administration	Hydration and early micturition can reduce dose to the genitourinary system
Technological advances	
Software	Iterative reconstruction Resolution recovery Noise reduction
Hardware	Solid-state camera

estimates of Marcassa and colleagues are likely to be over-estimates.

Nevertheless, the study by Marcassa and colleagues provides three important lessons. First, 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 (Table 1). These include weight-based determination of administered activity and the 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 for MPI, with a 58 % reduction in average effective dose observed over the course of the study.

Despite this marked radiation dose reduction, one could contend that the authors have not 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]. Performing stress imaging on the first day should obviate the need for rest imaging in the many patients whose stress images show normal perfusion, left ventricular function and wall motion on physician review prior to rest imaging [7]. For example, in a series of 27,540 consecutive MPI patients over an 8-year period, 16,854 patients (61 %) showed normal myocardial perfusion, and in 48 % of these rest imaging could be avoided [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 doses to physicians that accompanies the reduction in doses to patients. By paying attention to reducing the exposure of our patients to radiation, in general we will 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 protocolled studies based on diagnostic reference levels suggested by the Italian Association of Nuclear Medicine, but later recognized that they could be improved in terms of radiation dosimetry. The 2005 EANM/ESC procedural guidelines for MPI in nuclear cardiology [12] demonstrate 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 the importance of updating guidelines, reference levels, and practice protocols to reflect the developing evidence base and our enhanced appreciation of the importance of radiation protection.

The situation in which we find ourselves, with MPI the single largest contributor to medical radiation burden in some regions, 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. The continuing efforts of Marcassa and colleagues to reduce, and reduce again, the exposure of patients to radiation in their laboratory should serve as a model for all of us.

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