EDITORIAL

The time is now: Dose reduction for myocardial perfusion imaging

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The field of cardiac CTA underwent a dramatic evolution over a decade's time from the early 2000's to the present resulting in a remarkable decrease in radiation exposure to the patient over a short period of time. Hardware, software, and protocol advances allowed for a potential 95% decrease in exposure starting with almost 20 mSv per study and ending with 1 mSv.[1,2] Scanners went from 4 slices to 320 slices, added prospective gating, tube current modulation, and iterative reconstruction in an effort to reduce exposure.[3] This rapid transformation was brought about by the emphasis on patient radiation exposure in the medical literature starting in the mid-2000's.[1,4]

Nuclear cardiology has been slower to respond. Despite the introduction of iterative reconstruction software and high-efficiency SPECT cameras in the previous decade,[5] these technologies have seen slow adoption rates into general practice. While high-quality computed tomography can no longer be performed without a newer generation multidetector CT scanner, myocardial perfusion imaging can continue to be performed with a 20-year-old dual-head Na-I SPECT camera. Unfortunately, the radiation exposure to the patient with such cameras also has not changed in 20 years. Another technique seeing limited adoption in the US is the utilization of stress-first imaging protocols which also have the potential to reduce radiation exposure to the patient by eliminating the rest isotope injection altogether.[6]

In this issue of the *Journal*, Songy et al. put together all of the recent advancements in nuclear cardiology into one large series of patients which further proves that radiation dose reduction is feasible in day-to day-practice with a combination of high-efficiency SPECT and stress-first protocols.[7] This French group is not a newcomer to high-efficiency SPECT, and has previously published on their experience with Tl-201 imaging.[8,9] Here, the authors report the outcomes of a year's worth of patients who had no known coronary disease and underwent adequate (>85% maximum predicted heart rate) exercise stress and subsequently had normal perfusion with a very-low-dose high-efficiency SPECT camera MPI protocol. Starting with 1901 patients, the authors analyzed 1400 subjects after 501 were excluded (230 due to abnormal stress perfusion results and 271 who did not achieve 85% of maximum predicted heart rate). The ECG response to stress was normal in 1212 (87%), abnormal in 71 (5%), and non-diagnostic in 117 (8%). A total of 1288 (92%) subjects completed follow-up of an average of 1169 days (40 months). There were 22 cardiac events at follow-up (5 cardiac deaths, 7 non-fatal MI's, and 10 non-urgent revascularizations) along with 16 non-cardiac deaths resulting in an annualized cardiac event rate of 0.55%. This finding is similar to several other papers which have investigated the prognosis of normal stress-only MPI studies performed using high-efficiency cameras.[10,11] Importantly, in this study, the mean effective dose for sestamibi was 0.93 ± 0.12 mSv and 0.81 ± 0.06 mSv for tetrofosmin.

And so, much credit should be given to this European group, and to a previous Israeli group,[12] for accomplishing and exceeding the goals laid out in 2010 in an ASNC Information Statement on recommendations for reducing radiation exposure to an average exposure of $\leq$9 mSv in 50% of MPI studies.[13] These goals, which

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were not very lofty to begin with, are unfortunately accomplished by very few US laboratories as it is.[14]

How does one accomplish this goal (assuming a standard 10 mCi rest and 30 mCi stress Tc-99m SPECT MPI protocol is 12.1 mSv of exposure)?[15] New software or hardware will get you there. Iterative reconstruction (½ time or ½ dose) software or a high-efficiency SPECT camera can decrease the injected activity to 5 and 15 mCi resulting in an effective dose of 6 mSv achieving the ASNC goal in all non-obese patients. The doses can be pushed even lower with high-efficiency cameras if desired. Stress-first protocols when they become stress-only can reduce the effective dose to 8.8 mSv for high-dose (30 mCi) stress or to 2.9 mSv for low-dose (10 mCi) stress. Given that the majority of currently performed MPI studies are normal (free of perfusion defects),[16,17] the ASNC goal can easily be reached.

So how are we doing at reducing radiation exposure as a Nuclear Cardiology community? Recent literature from the International Atomic Energy Agency (IAEA) found that the mean effective dose for MPI studies (including PET) was 10.9 ± 4.4 mSv in the US and 9.7 ± 4.5 mSv in non-US laboratories.[14] This equates to only 24% of patients reaching the $\leq$9 mSv goal in the US and 43% in non-US laboratories. Of six geographic areas surveyed, North America fared the worst at utilizing a stress-first protocol with only 7.7% use compared to 84% in Europe, 68% in Asia, and 90% in Africa.[18] Other work by the IAEA found that avoiding excessive doses of Tc-99m could reduce the overall effective dose to patients by 3.1 mSv, stress-only imaging could reduce it by 2.3 mSv, and camera-based technology by 1.2 mSv.[19] Therefore, despite having the tools of reconstruction software, solid-state camera hardware, and stress-first protocols available to dramatically reduce patient radiation exposure, it is not being routinely employed in the US.

And yet, Songy et al. are able to achieve a mean effective dose of 1 mSv in their cohort which is a 90% reduction in radiation exposure compared to a standard rest-stress protocol. How do they do it? They use a new high-efficiency SPECT camera, the nuclear cardiology technological equivalent to increasing the number of slices on a multidetector CT. The high-efficiency SPECT cameras have significantly increased photon sensitivity and improved energy resolution achieved by redesigned collimation methods, dedicated scanner geometry, solid-state photon detectors (Cadmium Zinc Telluride), and camera-specific iterative reconstruction algorithms.[5] However, unlike the progressive updating of multidetector CT technology which has occurred over the past decade, the same turnover has not been seen in nuclear cardiology equipment. Songy et al. are also able to routinely integrate stress-first imaging into their workflow, an aspect of stress testing where European practices are ahead of the US. The hurdles to implementing a stress-first workflow are well known, including the need for attenuation correction, real-time review of stress images, and differential reimbursement for single- or multiple-image MPI studies in the US.[20] The actual nuts and bolts practical implementation of their stress-first protocol is unfortunately not shared with us in their manuscript for us to duplicate and take back to our own laboratories.

Nuclear Cardiology continues to play catch up in this important aspect of competition between non-invasive diagnostic modalities. To remain relevant to twenty-first century medicine, we must utilize the solutions provided to us to modernize our field as a whole. It is not acceptable for there to only be pockets of Nuclear Cardiology imaging excellence (i.e., the 3.1% of North American sites performing stress-only imaging),[18] the entire field must adhere to high standards. Nuclear Cardiology as a subspecialty is only as strong as its weakest link. Songy et al. have shown us the way. *Allons-y*. *Vite*!

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