Nuclear cardiology as it should look in the twenty-first century

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The currently used Tc-99m-based myocardial perfusion imaging (MPI) protocols were developed over 25 years ago. Considering the length of the tests (4 hours), consequent inconvenience to the patients, and radiation doses (>12 mSV), the decline in competiveness with other non-invasive modalities used for the diagnosis of coronary artery disease (cardiac CTA and stress echocardiography) seen in recent years becomes apparent. For SPECT MPI to remain relevant, the field must evolve which requires new approaches to the old problems. Recent technological advances (new software and advent of high-efficiency cameras) present the field an opportunity to emerge into the twenty-first century reinvigorated. European practices (mostly performed and regulated by non-cardiologists) are ahead of the United States in one important respect: the stress portion of the test is done first and the rest portion is done selectively only if needed.

In this issue of the *Journal*, Sharir et al from Assuta Medical Center in Tel Aviv tested a combination of a stress-first protocol and low tracer doses using a high-efficiency SPECT camera for its diagnostic accuracy.[1] They evaluated 284 patients without known CAD undergoing stress-first imaging, 208 of which underwent coronary angiography. Diagnostic performance using automated quantification of the stress perfusion images was compared in patients who underwent a ''half-dose'' 5 mCi stress/15 mCi rest protocol to those who had a ''standard dose'' 10 mCi stress/30 mCi rest protocol during different time periods. The very low-stress dose (5 mCi) used in this work is below the 10 mCi low-dose stress-first protocol used with conventional Na-I cameras (even with iterative reconstruction ½ time software) and is made possible by the high-efficiency SPECT camera hardware employed. As expected, sensitivity, specificity, and accuracy were acceptable and similar in the low and standard tracer dose groups.

In 2010, an ASNC Information Statement on recommendations for reducing radiation exposure suggested that by 2014 on average a total radiation exposure of ≤9 mSv could be achieved in 50% of MPI studies.[2] Determining whether this goal has been met in general clinical practice is problematic, but one cannot argue that we do not have the tools to easily achieve this goal. High-efficiency SPECT cameras, new iterative reconstruction ½ time software on conventional SPECT cameras, as well as a stress-first approach to most patients can all achieve this goal individually and in combination.

The reduction in effective dose to the patient which was seen in the current study was impressive (Figure 1). The average doses of 10.2 and 30.3 mCi in the standard dose protocol results in 11.7 mSv of exposure which is reduced by 74% to 3 mSv when a stress-only study is performed. When high-efficiency SPECT technology is added by cutting the administered activity in half, further reduction in effective dose by 42% is achieved. The ½ dose stress-rest protocol of 5 and 15 mCi results in 6.9 mSv of exposure which is cut to 1.7 mSv if a stress-only study is performed. Thus, a stress-only study with standard doses or a stress-rest or stress-only with ½ doses will achieve the ASNC 2010 goals. Previous papers focused on the selection of patients with expected normal stress images for a stress-first protocol. The current paper extends the stress-first protocol to all patients without known CAD. Even in the cohort that

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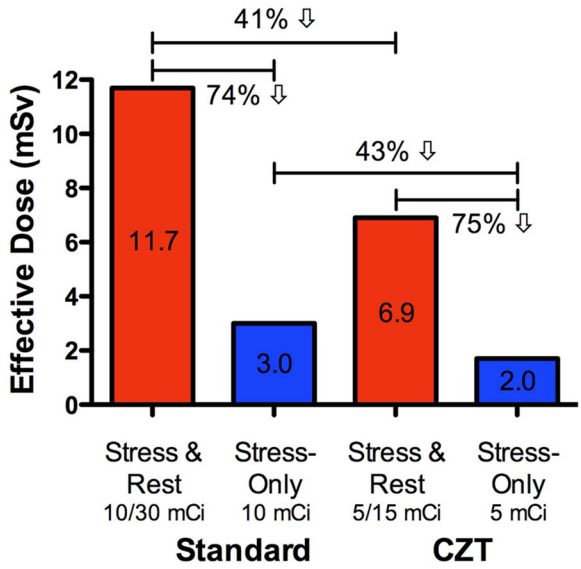

Figure 1. Effective dose reduction achieved with stress-only imaging and high-efficiency CZT SPECT technology.

subsequently underwent coronary angiography (i.e., bias toward more abnormal studies), stress-only imaging was possible in 21.5% of the patients studied.

Previous work on high-efficiency SPECT has focused on imaging time reduction, dose reduction, or both.[3] The key characteristic of the new high-efficiency SPECT cameras that allow these advances is significantly increased photon sensitivity.[3] The higher sensitivity is primarily achieved by a radical redesign of the collimation methods, but the overall system sensitivity is improved further by dedicated scanner geometry. Optimized scanner geometry achieved by replacing the traditional bulky combination of scintillation crystals and photomultiplier tubes with solid state photon detectors [Cadmium Zinc Telluride (CZT)] allows for the simultaneous collections of a higher fraction of counts from all directions without camera rotation by surrounding the patient with detectors. The use of solid state detectors also results in improved energy resolution and consequently fewer undesirable scatter events. While previous studies have included patients undergoing a stress-first protocol,[4-7] or apply automated quantification to high-efficiency cameras,[8-10] this is the first to limit enrollment to only stress-first patients and apply automated quantification to low or very low-dose stress images.

MPI is traditionally conceptualized as two sets of images, rest and stress, with the purpose of the rest images being the determination of whether any stress perfusion defects are reversible (ischemia) or fixed (infarction or attenuation). When stress MPI is normal, however, the rest image becomes superfluous.[11] Interestingly, when Tc-99m tracers originally became available, the development of the ''same-day protocols'' included the evaluation of a rest-stress versus a stress-rest sequence. Heo et al compered the two protocols in 32 patients finding that the sensitivity, specificity, predictive accuracy, and detection of ischemia were identical using a 1:3 low-dose to high-dose ratio.[12] Prophetically, the authors concluded: ''An issue to consider is that if the initial exercise images are normal with the exercise/rest sequence protocol, then there is no need to perform the rest images.''

It is now obvious that the stress-first strategy provides high-quality perfusion data equivalent to a full rest-stress study,[13] while saving time in the imaging laboratory and reducing radiation exposure both to the patients and to the laboratory personnel.[11,14] Yet only a minority of nuclear cardiology laboratories employ a stress-first protocol perhaps reflecting challenges such as the need for attenuation correction, feasibility of real-time review of stress images, and concerns about reimbursement.[15] There are ways to overcome the real or perceived obstacles to the implementation of more progressive approaches to SPECT imaging: (1) Attenuation correction in 2015 should ideally include hybrid imaging with CT with the ability to quantify calcium scoring. ''Second best'' is the use of prone imaging, as used in the current study, which does not represent any additional monetary investment, and in the case of shortened imaging times with high-efficiency SPECT, is not a great imposition on patient and personnel time. (2) If a physician is not immediately available, review of stress images with real-time decision about the need for rest imaging can be answered by the use of an automated software read, as was used in the current study. Other options would include a preliminary read by an experienced nuclear technologist or a remote read by a physician using networked computers or tablets. (3) Last, but not least, current ASNC guidelines for SPECT imaging urgently need an upgrade, which will reflect changing technologies and clinical demands. These new guidelines are due later this year.

Recent articles investigating the temporal trends of abnormal or ischemic MPI study results in large clinical cohorts have consistently demonstrated high proportions of normal studies.[16,17] In a study by Rozanski et al of 39,515 patients with no history of CAD that underwent diagnostic stress MPI from 1991 to 2009, the prevalence of normal MPI studies was noted to have increased among all subgroups from a prevalence rate of 59.1% in 1991, to 91.3% in 2009.[16] In a recent multicenter study of 108,654 patients undergoing clinically indicated stress MPI studies, an overall increase in the prevalence of normal studies was seen from 1996 to 2012 in all patients (46.2% to 68.2%), patients without CAD

(67.8% to 82%), and patients with CAD (25.3% to 39.2%).[17] If only half of the patients who undergo a stress-first protocol are normal and do not undergo rest imaging, the ASNC goal could be met solely by converting a laboratory to a stress-first approach instead of the standard rest-stress structure of most nuclear laboratories.

With the increasing prevalence of normal MPI studies, it is imperative that we develop more efficient protocols with less radiation exposure for the initial evaluation of patients who are presently at low risk for abnormal findings during stress MPI studies, and stress-first protocols represent an attractive option. The current paper adds to the substantial body of evidence confirming the feasibility, utility, and diagnostic performance of simplified, speedy, and radiation poor SPECT MPI protocols that need to be adopted in order to keep SPECT imaging relevant and competitive for years to come.

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