Implementation of stress-only imaging: What will it take?

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There is increasing national emphasis from health care policy makers and governmental organizations to reduce radiation exposure, streamline patient evaluations, and reduce costs as related to stress myocardial perfusion single photon tomographic (SPECT) imaging. One simple approach for achieving these goals, even without investing in new high-efficiency gamma camera technology and sophisticated software programs, is to change from a traditional rest-stress technetium (Tc)-99m imaging protocol to that of a stress-first imaging sequence. Using a stress-rest protocol, stress-only imaging can be performed with avoidance of the rest study if the stress study is normal. Recent data indicate that most patients evaluated for suspected coronary artery disease (CAD) will ultimately have a normal SPECT and would be potential candidates for stress-only imaging.[1]

STRESS-ONLY IMAGING: WHERE DO WE STAND?

Reluctance towards implementing stress-only imaging was initially due to inherent skepticism regarding its safety as compared to an integrated interpretation of two image sets (stress and rest). However, recent observational prognostic studies in >30,000 patients have demonstrated the feasibility and long-term safety of a normal stress-only study versus conventional SPECT imaging (Figure 1) and with marked reductions in radiotracer dose and radiation exposure.[2,3] In the study by Chang et al, the mean Tc-99m dose was 21.3 mCi with stress-only vs 55.1 mCi with stress-rest imaging and with 60% of stress-only patients receiving <5 mSv radiation exposure.[3,4] Reductions to 1-2 mSv can be achieved when combining stress-only imaging with Cadmium Zinc Telluride (CZT) SPECT.[5] Furthermore, Duvall et al recently reported 40-50% reductions in total body (deep and shallow dose) occupational exposure to laboratory personnel when combining stress-only imaging with CZT technology (Figure 2).[6] These advantages with stress-only imaging have led to its endorsement by the American Society of Nuclear Cardiology with a goal to reduce radiation exposure to <9 mSv in >50% patients.[7] There have also been no less that 3 recent editorials encouraging the nuclear cardiology community to embrace a stress-only approach.[4,8,9]

Despite this backdrop, stress-only imaging has yet to gain momentum in the United States or for that matter around the globe. The recent IAEA Nuclear Cardiology Protocol Study (INCAPS) showed only a small minority of nuclear cardiology laboratories worldwide (30%) and particularly in North America (16%) perform stress-only imaging.[10] In this regard, North America which has one of the highest rates of per capita nuclear cardiac imaging also had the lowest rate of patients undergoing stress-only imaging (3.1%) (Table 1) and with only 30% of patients receiving <9 mSv radiation exposure (Figure 3).[10,11] The reasons why stress-first imaging has not been widely adopted as the preferred imaging protocol are many and include: (1) the requirement to assess each patient at the time of their arrival to the laboratory so as to choose the most appropriate imaging protocol rather than a ''one test fits all'' approach (2) the need for staff flexibility so as to manage daily patient flow and (3) the perception that a physician must be readily available to interpret a study and ensure that it is interpreted correctly as normal based on less imaging information. A further important disincentive in the

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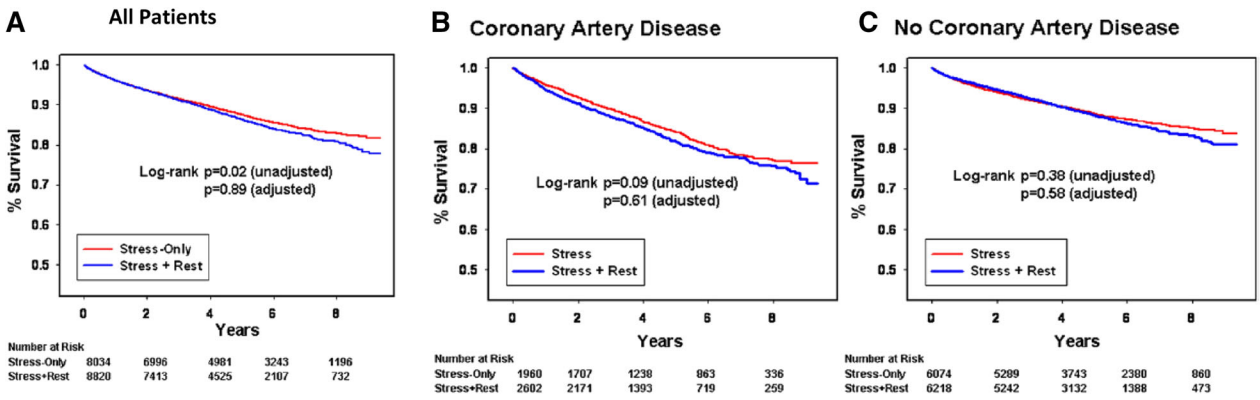

Figure 1. Survival Curves in all patients (**A**) and in patients with (**B**) and without (**C**) coronary artery disease based on stress-only versus stress-rest imaging. From Chang et al.[3]

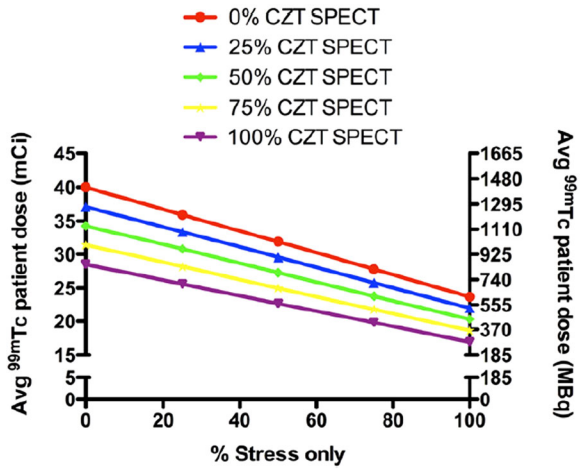

Figure 2. Potential reduction in total patient dose based on traditional 10/30 mCi rest-stress Tc-protocol with variable use of stress-only imaging and high-efficiency CZT SPECT. From Duvall et al.[6]

United States is current lower remuneration for performing a stress-only ($355.74) v conventional stress-rest ($492.65) imaging study despite additional physician time and inconvenience.[12] Furthermore, in some states if a patient is pre-approved for a stress-rest procedure, payment may be denied if a stress-only procedure is performed.

STRESS-ONLY IMAGING NEW INSIGHTS: THE CURRENT STUDY

In this issue of the Journal, Chaundhry et al[13] report a prospective study exploring the importance of incorporating technologist and quantitative software assistance in facilitating stress-only imaging. In this study, 250 patients were enrolled from 2 clinical laboratories (Hartford Hospital and Mount Sinai Hospital) to undergo stress-first imaging. The decision to perform stress-first imaging was determined by the onsite nuclear cardiologist based on available clinical and ECG data. Patients with known CAD were not excluded if they had a previously normal stress SPECT or stress echocardiogram study, non-obstructive CAD on invasive or CT coronary angiography or an abnormal coronary artery calcium score. Patients underwent stress-first imaging using either a conventional NaI or CZT high-efficiency SPECT camera. Importantly, all patients underwent attenuation correction on both cameras and additional prone imaging with the CZT camera. Technologists at each site were chosen to specifically evaluate whether or not a patient needed additional rest imaging based on the stress-first images, raw image data and gated information if available. Of note, these technologists all had previous experience with stress-first imaging protocols and had worked in nuclear cardiology for a mean of 13.4 years. Concurrent and independent of the technologist assessment, a board-certified nuclear cardiologist also determined whether rest imaging was required blinded to medical history and stress test results. The reference standard regarding need for rest imaging was based on a final decision by the interpreting nuclear cardiologist after review of all stress imaging data in addition to the patient's clinical presentation, past medical history and stress test data. In this study, quantitative polar plot analysis of all initial stress SPECT images was also performed to determine whether this could improve the decision-making process [based on a specific cutoff of total perfusion deficit (TPD)] beyond visual assessment alone.

The patient's enrolled were typical of those evaluated with stress SPECT: mean age 61 years; multiple risk factors for (and 6% with known) CAD; 55% women; and mean body mass index (BMI) of 29.4 kg/m^2. Approximately 53% of patients had exercise stress and the remainder pharmacologic stress testing. Sixty

Table 1. INCAPS: Imaging Protocols used and radiation effective doses received by patients based on geographic region

Patients	Africa 336	Asia 1077	Europe 2130	Latin America 1033	North America 1734	Oceania 405	Total 6715	*P* value
Rest-first, %	34 (10.1)	343 (31.8)	333 (15.6)	613 (59.3)	1601 (92.3)	320 (79.0)	3244 (48.3)	<.001
Stress-first, %	302 (89.9)	734 (68.2)	1797 (84.4)	420 (40.7)	133 (7.7)	85 (21.0)	3471 (51.7)	<.001
Stress-only, %	109 (32.4)	122 (1.3)	422 (19.8)	53 (5.1)	54 (3.1)	40 (9.9)	800 (11.9)	<.001
Effective dose, msv								
Non-stress-only mean ED (SD)	12.8 (4.2)	11.2 (2.6)	9.0 (2.5)	12.4 (3.5)	12.0 (3.0)	9.9 (3.0)	11.0 (3.2)	<.001
Stress-only mean ED (SD)	3.9 (2.4)	3.7 (1.7)	3.9 (1.4)	5.4 (1.9)	5.2 (3.0)	2.3 (0.7)	4 (1.9)	
Mean ED difference	8.9	7.5	5.1	7.0	6.8	7.6	7.0	
% decrease in mean ED	69.5	67.0	56.1	56.5	56.7	76.8	63.6	

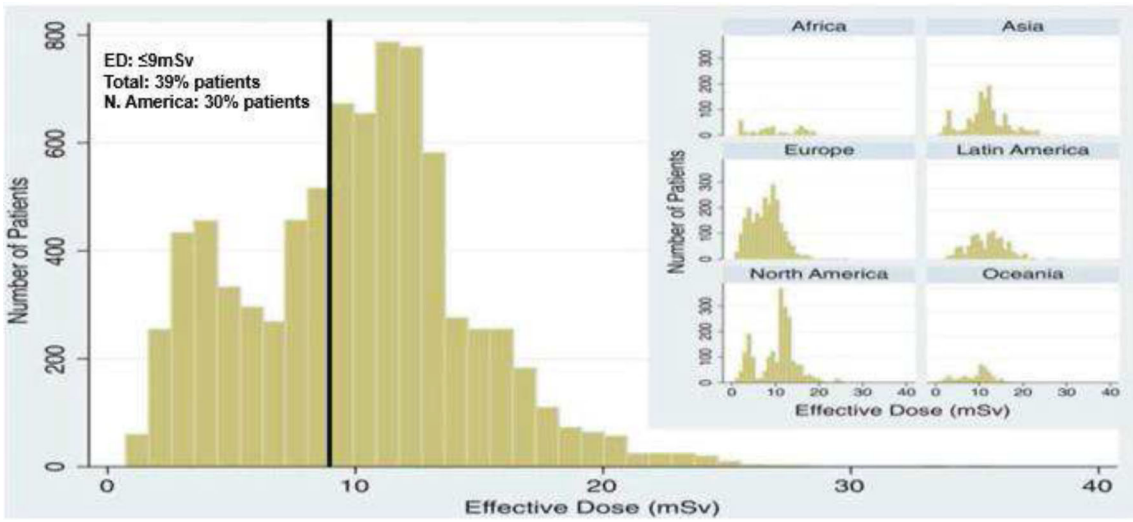

Figure 3. Worldwide distribution of patient radiation doses from myocardial perfusion imaging overall and in different geographic regions. From Einstein et al.[10]

percent of patients underwent imaging on a conventional NaI gamma camera.

Based on the reference gold standard nuclear cardiologist assessment, 208 (83%) patients did not require rest imaging. Technologists correctly classified 91.6% of patients as either needing or not needing rest imaging which was similar to that of the blinded nuclear cardiologist (93.6%) (overall agreement 91.6%, k = 0.671). Of the 21 patients misclassified by technologists, 14 (5.6%) patients were incorrectly not referred for additional rest imaging of whom 7 were ultimately interpreted as normal. The blinded nuclear cardiologist misclassified 9 (3.6%) patients who required additional rest imaging.

The quantitative automated software (based on a TPD of ≥1.2% defined by optimal receiver operator characteristic curve analysis) correctly classified only 71.6% studies primarily due to incorrectly requesting rest images in 60 (24%) patients as compared to only 2.8% by technologists and blinded nuclear cardiologists. This is not unexpected since quantitative programs based on comparison to gender specific normal data files

frequently show small perfusion defects due to attenuation and other imaging artifacts. By increasing the TPD to >2 and >3, specificity improved with sacrifice of sensitivity. The authors simulated a combined technologist and quantitative analysis outcome such that if the technologist or computer chose the correct rest imaging decision, it was counted as an agreement with the reference standard. In this model 96.8% of studies were correctly classified with only 7 studies misclassified as not needing rest imaging (2.8%) which was similar to that of the blinded cardiologist's visual assessment (3.6%).

STRESS-ONLY IMAGING: REMAINING HURDLES

The current study nicely portrays a potential approach for successfully implementing a stress-first imaging protocol by empowering the nuclear technologist and thereby limiting the need for initial physician input. However, there remain several caveats. In this study, it is unclear how many patients were screened by the nuclear cardiologist to find the 250 patients who were good candidates for a stress-first imaging protocol. The high rate of normal studies (83%) might indicate ''cherry picking'' of particularly low risk patients. However, recent data from the Cedar Sinai registry of 39,515 patients without known CAD studied from 1991 to 2009 indicates a significant decrease in abnormal SPECT results from 41% to 8.7% over that time span—consistent with the current study.[1] In our own hospital-based patient series spanning years 2000 to 2007, 16,854 of 27, 540 patients (61%) had a normal stress SPECT even though patients with known CAD and/or prior revascularization procedures (31%) were included.[3] Of note, in our study, a similar percent of patients with and without known CAD (49% vs 42%) had a normal stress-only study. In this regard, there appears to be no shortage of patients who when referred for imaging will have a normal SPECT result thereby further supporting the importance of performing stress-first imaging.

Secondly, with the rise in obesity there may be concern from a practical standpoint that soft tissue attenuation artifacts may significantly limit identifying normal patients without a comparison rest study. In this regard the mean BMI in the current study was 29.4 ± 6.8 kg/m^2 and yet most patients did not require rest imaging—although attenuation correction techniques were routinely used. In a recent study, using stress SPECT to risk stratify patients prior to bariatric surgery (mean patient BMI 49 kg/m^2), 89% had a normal study and 67% were normal based on stress-only results.[14] In our series, 33% of patients had a BMI > 30 kg/m^2.[3] In this regard, a successful stress-only program should not be limited by body size.

Thirdly, as noted in the current study, it is imperative to have experienced technologists who are skilled at SPECT interpretation. In this study, well-trained technologists performed as well as physicians when deciding when a patient did or did not require rest imaging. Nuclear societies need to provide the educational tools for improving technologist interpretation skills but this also needs to be done at a laboratory level by the medical director. In our own laboratory, we have monthly quality assurance meetings where we review interesting cases with artifacts and physicians have daily interaction with our staff regarding image quality and interpretation. Most studies will clearly be normal and not require immediate physician input; however, in our laboratory technologists are encouraged to call us regarding all questionably normal studies.

Lastly, a novel aspect of the current study was to model the integrated use of quantitative software and technologist results for deciding whether a study was normal. The integrated model showed that only 2.8% of patients were misclassified as not needing rest imaging as compared to 5.6% by visual inspection alone, however, the effect of quantitative analysis on technologist decision-making was not directly assessed. We have successfully employed quantitative analysis in our own laboratory such that if a study appears visually normal to a technologist and the TPD is zero at a 2.5 standard deviation cutoff, rest imaging is not performed. Since commercially available quantitative software package algorithms and normal data files vary, all laboratories performing quantitative analysis must become comfortable with how their software performs in patients who have visually normal SPECT studies.

Implementing stress-only imaging—what will it take? The study by Chaundhry et al emphasizes the need for an integrated laboratory approach with well-trained technologists at the front line of study interpretation under the guidance of interpreting physicians. In addition, reimbursement issues will remain a critical issue in ''moving the needle'' towards a stress-only approach. The launch of the ImageGuide registry by the American Society of Nuclear Cardiology will provide a springboard for quality assurance in nuclear cardiology and ultimately promote a dialoge with health insurance providers regarding need for payment reform.

Disclosure

The authors have no conflict of interest to disclosure.

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