

Technical Advances in SPECT Myocardial Perfusion Imaging

INTRODUCTION

Looking back on 4 decades of nuclear cardiology, it is remarkable how far the field and single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) technology has come. Today, nearly 8 million SPECT MPI scans are performed each year,¹ and SPECT is accepted as a powerful modality for assessing cardiac perfusion and function to diagnose coronary artery disease, assess risk, and guide management decisions. The field continues to evolve, with exciting advances in SPECT MPI technology—hardware, software, protocols, and new applications—that focus on improving lab efficiency, reducing radiation exposure, increasing patient comfort, and improving image quality (Table 1).

REDUCING RADIATION EXPOSURE

In the US, the prevalence of and mortality associated with risk factors for coronary heart disease, particularly obesity and diabetes, continue to increase and these risk factors are manifesting at earlier ages.³ Coupled with a general increase in life expectancy,⁴ the number of imaging procedures a person will undergo during his or her lifetime is expected to rise.⁵ Cardiac imaging procedures, including angiography, cardiac CT, and radionuclide imaging, expose patients to small amounts of ionizing radiation.^{5,6} Responding to growing concern about cumulative radiation exposure from imaging procedures, cardiac imaging techniques and appropriate patient selection algorithms are being implemented that strive to limit individual patient radiation exposure while still maintaining image quality.⁵ Strategies to reduce patient radiation exposure in SPECT MPI include reducing tracer dose and using resolution recovery software to maintain image quality with lower-count image acquisitions.² New SPECT cameras and imaging techniques that require less radiotracer may also help labs meet the challenges posed by the current technetium shortage.

IMPROVING PATIENT COMFORT

Improving the patient's experience during a SPECT MPI scan can impact image quality by reducing patient motion and the potential for motion artifacts.² New camera designs allow patients to be imaged upright or reclining, with no need to raise their arms as required during supine imaging.²

Table 1. Technological advances in SPECT MPI.²

HARDWARE	SOFTWARE
<ul style="list-style-type: none"> ■ Cardius® 3 XPO (Digirad) ■ CardiArc® (CardiArc) ■ D-SPECT™ (Spectrum Dynamics) ■ Discovery NM 530c with Alcyone™ technology (GE) ■ IQ SPECT™ (Siemens) 	<ul style="list-style-type: none"> ■ nSPEED® (Digirad) ■ Astonish™ (Philips) ■ Evolution for Cardiac™ (GE) ■ Flash 3D™ (Siemens) ■ Wide Beam Reconstruction™ (WBR; UltraSpect)
PROTOCOLS	STRESS AGENTS
<ul style="list-style-type: none"> ■ Stress only + attenuation correction ■ Early poststress imaging ■ Rapid dual-isotope 	<ul style="list-style-type: none"> ■ Adenosine receptor-mediated pharmacologic stress

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New SPECT cameras have been developed that have cut MPI image acquisition to one-half and even one-quarter the standard time (15-20 minutes for each stress and rest acquisition).² In addition to the potential benefits of fast SPECT on lab throughput and scheduling, reducing acquisition time also increases patient compliance and comfort, thus decreasing motion artifacts.² These cameras have optimized acquisition geometry, new detector materials, and collimator designs that allow better sampling of myocardium and higher spatial resolution and sensitivity at greatly reduced acquisition times.² Because the new SPECT cameras detect a higher number of counts specifically from the myocardium, it is possible to preserve or improve image quality, despite shorter imaging times.²

MAINTAINING IMAGE QUALITY

SPECT MPI protocols that either use less radiotracer or reduce image acquisition time produce fewer detected counts. In an effort to overcome the well-known tradeoff between sensitivity and resolution, new reconstruction software has been developed to improve image contrast and reduce noise levels inherent in low-count images, correcting for scatter and attenuation and preserving image resolution (Figure 1).²



Figure 1. New SPECT MPI cameras and image processing software make it possible to reduce either image acquisition time or the radiotracer dose while maintaining image resolution and quality.



NEW SPECT MPI PROTOCOLS

Several new SPECT protocols are being developed to reduce scan time, optimize SPECT utilization, and potentially improve patient compliance and lab efficiency. For patients with low pretest risk or who can exercise, stress-only imaging with attenuation correction may be sufficient to rule out disease.^{7,8} ASNC released a clinical update in 2009 approving the use of stress-only imaging protocols in certain patients, who would undergo a rest test only if there is an abnormality on the stress images, or if other risk factors (eg, clinical risk factors, abnormal ECG) suggest the potential for coronary heart disease.⁹ To ensure accuracy, stress-only studies are carried out with or without attenuation correction, or by imaging patients supine with gating and prone without gating.⁹ Stress-only imaging has the potential to reduce patient and staff radiation exposure, unnecessary rest scans, and time and healthcare costs.^{9,10}

Protocols that acquire images very early after stress administration, prior to liver and bowel uptake, are also being evaluated.^{11,12} In preliminary studies, SPECT MPI images acquired less than 6 minutes after radiotracer injection showed equivalent subdiaphragmatic activity and degree of patient motion, as well as similar perfusion defect scores and left ventricular ejection fraction (LVEF) measurements, compared with images acquired at standard acquisition times.¹¹ Application of scatter correction methods during image reconstruction may improve early post-stress image interpretation by separating myocardial and gut activity.¹² Another new protocol that may be possible using new SPECT (collimator) materials in high-speed MPI scanners is a rapid dual-isotope protocol, with stress-rest images acquired in less than 20 minutes.¹³ Finally, advances have been made in the field of adenosine receptor-mediated pharmacologic stress agents.

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ICANL ACCREDITATION¹⁴

Recognizing the potential impact of the recent technological advances in SPECT MPI on patient care, the Intersocietal Commission for the Accreditation of Nuclear Medicine Laboratories (ICANL) developed a set of provisions that must be met by laboratories that utilize new SPECT technology or parameters outside of the currently accepted ICANL Standards. Laboratories must demonstrate clinical validation of the new technologies, showing that they can produce clinical results that are reproducible and equal to or better than currently accepted technologies, based on published, peer-reviewed data.

Laboratories that use standard imaging equipment with new imaging reconstruction software, or that use new hardware technology not incorporated into published imaging guidelines, are required to (1) perform physiologic phantom studies using their laboratory's new imaging parameters to demonstrate defect and image reproducibility, (2) submit results of quality control testing, and (3) perform adequate training of the technical staff relevant on the new technology.

CONCLUSION

The field of nuclear cardiology is experiencing an extraordinary period of innovation and technological advance, from new cameras with novel detector materials and detector array geometries that allow image acquisition in a fraction of the time needed with standard cameras; to new reconstruction software that can maintain image resolution with low-count data acquisition; to new, faster SPECT MPI protocols. These advances hold the potential to increase patient comfort and compliance, reduce radiation exposure to the patient and staff, and improve lab efficiency.

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