The evolution of myocardial perfusion imaging has taken many twists and turns over the years as both equipment technology and new radiopharmaceuticals have developed. At one time, the very application of physiologic imaging to exercise stress in order to improve the accuracy of coronary artery disease diagnosis was considered quite innovative. That early planar imaging of thallium-201 uptake by the myocardium at stress, and its comparison with the distribution at rest to detect ischemia or scar, was a huge advance toward the goal that has consistently driven Nuclear Cardiology from its beginning: the identification of those patients who are at risk for myocardial infarct or death.

SPECT

The introduction of single photon emission computed tomography (SPECT) considerably improved diagnostic accuracy and allowed better estimation of infarct size and/or ischemic burden. Subsequent development of several technetium-99m tracers, notably Tc-99m sestamibi and Tc-99m tetrofosmin, further improved image quality. The addition of ECG-gating to image acquisition brought still another dimension of left ventricular functional information to further refine perfusion pattern interpretation, particularly in differentiating true perfusion defects from soft tissue attenuation artifacts.

Significant software contributions have allowed standardization and quantification of these perfusion and function parameters. These software programs have allowed standardized estimates of regional perfusion and ventricular contractility compared to normal databases as well as reproducible calculations of left ventricular volumes and ejection fractions [1].

With all these enhancements, SPECT myocardial perfusion imaging has been well validated over the years and has become widely accepted for its incremental diagnostic and prognostic value in clinical decision making. Nonetheless, development has slowed and no major improvements have occurred in the last 15-20 years. Also, true absolute quantification of important physiologic parameters such as myocardial blood flow has remained elusive.

PET

Positron emission tomography (PET) has emerged as a similar radiopharmaceutical tomographic imaging technique to SPECT, but with important and unique characteristics. It has inherently higher image resolution and is capable of providing accurate physiologic measurements.

Pioneering work in demonstrating the myocardial perfusion imaging capabilities of

The goal of Nuclear Cardiology is the identification of patients at risk of myocardial infarct or death.
PET [2] did not result in immediate widespread use of PET, primarily due to the limited availability of equipment and PET radiopharmaceuticals. However, with the parallel evolution of PET as a powerful diagnostic tool in oncology, PET has entered into the diagnostic imaging mainstream. The availability of rubidium-82 via onsite strontium-rubidium radiopharmaceutical generators has also allowed myocardial perfusion imaging with PET to expand, since this PET tracer is available upon demand.

**Comparison of PET and SPECT**

For cardiology applications, PET offers improved image resolution when compared with SPECT [3], enhancing detection of abnormalities in regional myocardial perfusion. This has been well established over the years, but more recent developments of iterative image reconstruction methods, time-of-flight PET acquisition, and PET quantitative software packages have further advanced accuracy. Direct comparisons of myocardial perfusion with PET and SPECT have documented the superiority of PET, especially in large patients and those with equivocal previous SPECT results [4].

In an ongoing comparison series, we have performed both Tc-99m sestamibi SPECT and Rb-82 PET on the same day in a group of patients undergoing a single pharmacologic stress protocol with dipyridamole infusion (Figure 1) [5]. This minimizes the variables inherent in most comparative studies and has demonstrated the superiority of PET with CT-based attenuation correction. The additional quantitative capabilities of PET for measurement of blood flow at rest and with vasodilator stress can add important physiologic information for clinical assessment, even when regional perfusion images appear not to demonstrate obvious ischemia or scar [6,7].

**Combination with CT**

A recent boost in acceptance of PET has resulted from incorporation of transmission tomography (CT) with PET as a combined PET-CT scanner unit. Originally conceived as an improvement for acquiring body density attenuation maps for attenuation correction of PET images, current generation units combine the state-of-the-art technologies of both PET and CT into units that have full capabilities for both modalities. Most notably, the fusion of physiologic PET images with the anatomic image information from CT (Figure 2) offers a powerful tool for disease assessment [8]. However, it also introduces new complexity in ensuring proper initial patient positioning, proper indexing of scan data sets by the imaging equipment, and minimization of both intrascan and interscan patient motion [9]. This assumes special importance when the imaging is used as a basis for planning intervention.

Attenuation correction has long been employed for PET utilizing external radiopharmaceutical sources. It appears that the combination with CT provides more reliable and faster attenuation correction and can also provide good comparative anatomic information, even when CT is typically used in a low-dose non-contrast mode.

Having state-of-the-art CT integral to PET adds further CT capabilities for calcium scoring and high resolution angiography if desired [10]. There is great interest currently in assessing the optimal combination of PET and CT imaging information that will provide the best “one-stop” evaluation of any individual patient. Multiple combinations of the two modalities can be customized to gain the desired clinical data at the lowest feasible radiation burden and cost for each patient.

These recent advances in PET-CT for cardiology have begun to translate back to single-photon tomography (SPECT) as well. Considered by
Figure 3. Tc-99m sestamibi SPECT-CT in a large male patient with a low clinical likelihood of coronary disease.

Figure 3a. Uncorrected short axis images demonstrate inferior diaphragm attenuation artifact.

Figure 3b. Uncorrected long axis images also show inferior diaphragm attenuation artifact.

Figure 3c,d. Corresponding attenuation-corrected images are normal.

Figure 4. Inferobasal infarct in a 63-year-old male patient.

Figure 4a. Tc-99m SPECT images showing a pattern of inferobasal infarct, but no ischemia.

Figure 4b. Rb-82 PET images showing a small inferobasal infarct, but with additional ischemia along the majority of the inferolateral segment.
many users to have gone through a period of developmental stagnation, SPECT technology is now benefiting from combination with CT into SPECT-CT scanner units to take advantage of the valuable integration of physiology and anatomy to improve diagnostic accuracy. CT-based attenuation corrected SPECT images appear to demonstrate similar incremental improvement in image quality and lesion conspicuity to that of PET-CT (Figure 3) [11].

**Case study**

A 63-year-old male patient presented with prior history of myocardial infarction and bypass surgery five years previously. Tc-99m SPECT images show a pattern of basal inferior infarct without ischemia (Figure 4a). Rb-82 PET images show a small inferobasal infarct but with additional ischemia along the majority of the inferolateral segment (Figure 4b). Coronary angiography demonstrated a patent LIMA graft to the LAD, patent vein graft to the RCA, and diffuse CMX stenosis, amounting to 100% distally.

**The future**

Even the near future of PET-CT and SPECT-CT cardiac imaging is difficult to foresee, especially with external forces of healthcare reform and economic regulation looming large. It is becoming clear that these new combination modalities are improving the detection and prognostic assessment of coronary artery disease in ever more quantitative fashion. As new radiopharmaceutical developments push us beyond simple detection of artery stenosis and more toward the earlier detection of atherosclerotic plaque and the very molecular basis of coronary vascular and myocardial function, these combined modality imaging technologies will be indispensable tools for the advancement of these discoveries.

**References**


