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EDITORIAL

Dynamic SPECT: evolution of a widely available tool for the assessment of coronary flow reserve

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Myocardial perfusion imaging (MPI) SPECT is well established in the diagnosis, monitoring response to treatment and risk stratification in patients with known or suspected coronary artery disease (CAD). PET enables quantitative assessment of myocardial blood flow (MBF, in millilitres per gram per minute) and coronary flow reserve (CFR), and quantification with ^{15}O-water, ^{13}N-ammonia and recently ^{82}Rb has been validated over a wide range of blood flows in animal models and humans [1–4]. Quantitative assessment of MBF has been shown to improve the diagnostic accuracy of conventional MPI with SPECT or PET, to improve cardiac risk assessment and to predict outcome [5–7]. Quantitation of MBF enables absolute assessment of myocardial flow and vasodilator reserve without the assumption of a normal reference region [8]. Therefore, the limitation of conventional MPI (underestimation of the extent and severity of multivessel CAD, when tracer uptake in the best-perfused myocardial region does not represent normally perfused myocardium) can be overcome by the use of absolute quantitation [9].

Whereas PET is very costly and complex, SPECT systems are widely used for the assessment of myocardial perfusion in patients for the diagnosis and management of CAD. However, quantitative assessment with SPECT has been limited. To enable quantitation with SPECT a multidetector system is required to permit fast acquisition of dynamic data in 5 – 10 s, and a suitable SPECT tracer is necessary. Transmission imaging for attenuation correction will allow accurate quantitation. Quantification of myocardial perfusion reserve has been attempted using SPECT and ^{201}Tl in dogs [10] and ^{99m}Tc-labelled tracers [10–12]. Dynamic SPECT imaging using multidetector SPECT systems and kinetic modelling of ^{99m}Tc-teboroxime has shown good correlation with microsphere-determined blood flow. However, limitations in detector sensitivity and temporal resolution of conventional SPECT systems prohibit further assessment [10, 11].

Another SPECT technique based on first-pass planar imaging followed by conventional SPECT MPI has been used to estimate a retention index of MBF and CFR [12]. This technique has shown a generally good correlation with PET-measured flow, but CFR is underestimated at high flow rates [13]. The use of a retention index to estimate CFR using this method compared to absolute MBF from PET results in an underestimation of CFR values in the SPECT-based technique, since tracer retention decreases with increasing blood flow [14]. Spatial and timing resolution are poorer with SPECT and the tracer retention index underestimates CFR compared to quantitative PET. SPECT is indeed simpler than PET but this technique, unlike PET, does not include dynamic acquisition of tomographic data. In addition, the technique works only for tracers that act like microspheres, showing a constant extraction over a large range of flow rates and showing no washout from the time of injection to the time of measurement.

Conventional SPECT systems are limited in the dynamic collection of tomographic data. These systems consist of slowly rotating cameras with large detectors. The detectors' orbit is limited by mechanical as well as safety factors and the angular projections obtained are inconsistent, resulting in blurred images and possible bias in the estimated kinetic parameters. In addition, conventional detector crystals suffer

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from limited temporal resolution, and may not be able to collect adequate numbers of counts when tracer concentrations are rapidly changing, such as in dynamic acquisitions.

Recently introduced dedicated cardiac cameras with cadmium zinc telluride (CZT) crystals provide significantly improved sensitivity (eight to ten times better than conventional SPECT) and significantly improved resolution and energy resolution [15, 16]. These improvements, in addition to allowing focused imaging of the heart and the use of new reconstruction algorithms, enable dynamic SPECT with kinetic analysis of ^{99m}Tc-MIBI myocardial concentrations to be performed in animals and humans [17–20], providing incremental diagnostic information over perfusion data alone [17]. Further studies are needed to assess whether availability of transmission to correct for attenuation may enable better modelling of ^{99m}Tc-labelled tracer kinetics. In addition, the new technology with superior sensitivity allows a significant reduction in the administered dose of ^{99m}Tc-labelled tracers [21–23], which should also be applied to dynamic SPECT in future studies.

With the increasing abundance of dedicated cardiac cameras with solid-state detectors, this technology offers great promise for CFR quantification with dynamic SPECT. However, further studies are needed for validation of this technique with PET measurements in large patient cohorts and with low administered activities, to establish its role in the clinical work-up of patients with known or suspected CAD and to provide data equivalent to the large body of data already accumulated for blood flow quantitation with PET tracers.

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Conflicts of interest Dr Ben-Haim is advisor to Spectrum-Dynamics.

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