Myocardial blood flow quantitation with the SPECT technique: Is it ready to be a substitute for PET myocardial blood flow quantitation?

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In the last ten years, myocardial blood flow quantitation (MBF) with the SPECT technique has been continuously investigated for its capability toward the clinical utilization. The outcome is to establish a widely available clinical tool that can offer an accurate measurement of MBF close to PET MBF quantitation for the diagnosis and prognosis of coronary artery disease (CAD). This clinical solution is particularly attractive and demanded for area (e.g., Asia and Australia) where PET MBF quantitation is not applicable due to the lack of suitable PET myocardial flow tracers as the main barrier. Even in areas (e.g., North America and Europe) where PET MBF quantitation is available, SPECT MBF quantitation still draws large interest because of its simplicity and lower cost to integrate into the SPECT user environment.

The fundamental requisite for SPECT MBF quantitation depends on three technical components: fast dynamic SPECT acquisition, suitable SPECT myocardial flow tracers, and dedicated software. Nowadays, SPECT myocardial flow tracers (^{99m}Tc-Sestamibi and ^{99m}Tc-Tetrofosmin) and dedicated software (4DM SPECT CFR, FlowQuant, QPET, and MyoFlowQ) are world-wide available. The remaining challenge comes

from the requirement of SPECT cameras capable of performing fast dynamic SPECT acquisition in at least 10-second time resolution to effectively image the rapid radiotracer distribution in myocardium. In fact, this fast dynamic SPECT acquisition mode is only applicable in certain SPECT camera models with NaI(Tl) detector and rapid rotating gantry (RRG) (e.g., Symbia SPECT and SPECT/CT family)^{1,2} or cadmium zinc telluride (CZT) detector and list-mode data acquisition (e.g., Discovery NM530c and D-SPECT),^{3–5} leaving the technique of SPECT MBF quantitation not implementable for all SPECT cameras currently serving in clinics. However, the situation may gradually change with the new installation of SPECT and SPECT/CT cameras containing this important function.

In the review article composed by Zavadovsky and et al, the current status of CZT-SPECT myocardial blood flow and reserve assessment are comprehensively reviewed, including imaging protocols, image corrections, validations with PET quantitation, angiography and fraction flow reserve, and technical/clinical limitations.⁶ This review article provides the most updated information in many aspects for readers to fully learn about SPECT MBF quantitation and is highly recommended for the interested. Compared with RRG SPECT, the major advantages of CZT SPECT are recognized as higher count rate and energy resolution that can allow for using lower-dose injection and less scatter contamination for correction. Another advantage is marked as the stationary gantry design to avoid a correction for angular inconsistency as required for RRG SPECT. Due to small image field-of-view, the disadvantage comes from the unavowed low-dose pre-injection for myocardium localization. While not appropriately corrected, myocardial uptake from the pre-injected dose can

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Figure 1. An example of CZT-SPECT MBF quantitation with and without the correction of low-dose pre-injection for myocardium localization. Arrows point to the first frame of dynamic polar maps having myocardial uptake due to the pre-injection.

introduce around 5%-20% bias to the flow data depending on the ratio of pre-injected and injected doses, rest/stress stages and individual patient (Figure 1). Nonetheless, RRG SPECT and CZT SPECT require full image corrections, including corrections for attenuation, scatter, spatial resolution (required for RRG), image noise, patient motion, tracer extraction, physiology variance in the rest, and the rest residual uptake in the stress data for the one-day protocol in order to perform accurate quantitation close to PET.⁷⁻¹⁰ Particularly, as attenuation correction is not applicable, the quantitation of rest and stress MBF in (ml/min/g) will be few times overestimated as myocardial flow reserve can still be preserved.^{5,11} Lacking attenuation and associated corrections would further prevent the implementation of stress-only protocol in patients without a history of myocardial infarction like PET MBF quantitation,^{12,13} which is the key to effectively reduce the patient radiation exposure and increase the laboratory efficiency. It is important to point out that when necessary image corrections are applied, both RRG SPECT and CZT SPECT can consistently quantify very close MBF values on the same cohort.¹⁴ In the Zavadovsky's review article, the clinical validation of SPECT MBF quantitation vs PET was carefully reviewed. As the accuracy of SPECT MBF quantitation is warranted, its clinical strength should be recognized as the strength of PET MBF quantitation in the detection of multi-vessel CAD, functional significance in intermediate coronary lesion (40%-90% stenosis), early

asymptomatic CAD, and microvascular dysfunction.¹⁵⁻¹⁸

It is generally believed the important role of SPECT MBF quantitation as a substitute for PET MBF quantitation is going on its way when more and more clinical data are being published. This accomplishment is expected and will continuously facilitate the clinical utilization of SPECT MBF quantitation, especially for areas where PET MBF quantitation is not accessible.

Disclosures

Drs. Fang, Huang and Hsu have nothing to disclose.

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