Quantification of myocardial blood flow and myocardial flow reserve with SPECT imaging technique

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Received Oct 14, 2017; accepted Nov 17, 2017
doi:10.1007/s12350-017-1152-0

Single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) is an established imaging technique to assess for myocardial ischemia, infarction, and viability. However, the technique still has its weakness where the balanced myocardial ischemia in the setting of multi-vessels coronary artery disease can be missed. Recently, there is revolutionary development in the field of the Nuclear Cardiology whereby the quantification of myocardial blood flow (MBF) and myocardial flow reserve (MFR) with an innovative Tc-99m Sestamibi dynamic-SPECT method had been established using solid-state gamma camera.[1] The quantification of the myocardial blood flow and myocardial flow reserve can be used to exclude balanced myocardial ischemia and to assess microvascular dysfunction where it is shown to be of great prognostic value.[2,3]

In this Images That Teach, we are presenting three cases: transmural infarct with inducible myocardial ischemia in patients with triple vessel coronary artery disease, dilated cardiomyopathy with microvascular dysfunction, and partial thickness infarct with microvascular disease in patients with post-percutaneous coronary intervention (Figures 1, 2, 3, and 4). The Dynamic radionuclide myocardial perfusion imaging of these three cases are performed with solid-state dedicated cardiac camera (D-SPECT; Spectrum Dynamics) using Tc-99 m Sestamibi.

The D-SPECT system comprised nine individual detector columns which rotate independently and are able to focus their scanning pattern on a fixed region of interest (ROI). The detectors performed a continuous step and shoot scanning pattern with multiple sweeps forwards and backwards during the dynamic scanning process. Each sweep comprised ten positions per detector columns over approximately 3 seconds. Radioactive tracer (Tc-99 m Sestamibi) is introduced to an injection line and placed in a shielded syringe carrier which is injected by automatic injector system.

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J Nucl Cardiol 2019;26:318–23.
1071-3581/$34.00

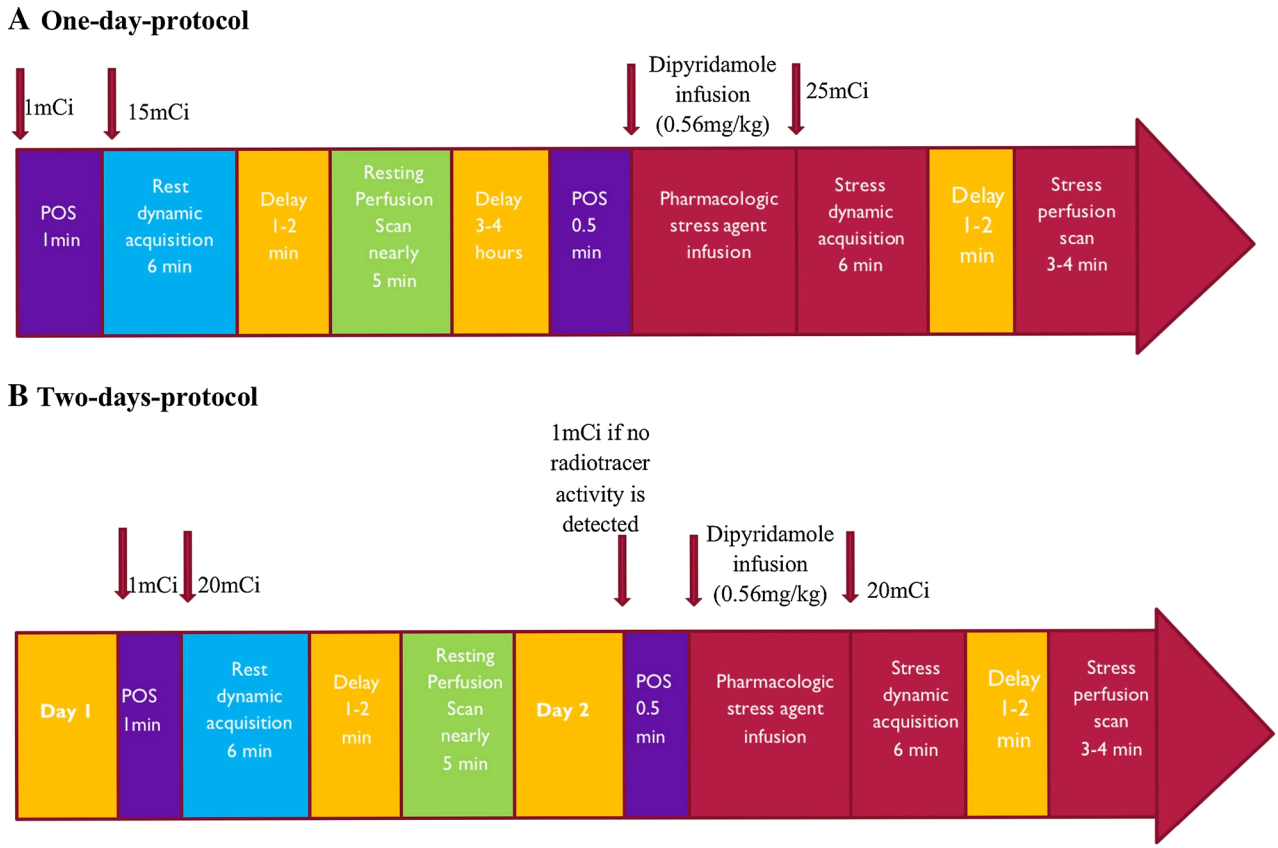

Figure 1. Protocol for dynamic-SPECT myocardial perfusion imaging **A** For rest dynamic imaging, an initial dose of approximately 1 mCi Technetium (99mTc) Sestamibi is injected in order to position (POS) patient's heart within the field of view while patient is in seated position on D-SPECT chair and to establish the scanning region of interest (ROI). The remaining dose of approximately 15 mCi 99mTc-sestamibi is then injected to patient preferentially via intravenous line placed at the antecubital fossa, followed by a flush volume of 35 mL normal saline to ensure consistent delivery of a tight bolus at 3 mL per second for about 13 seconds. Rest dynamic images are acquired in list mode over 6 minutes. Following the rest dynamic scan, rest perfusion scan is acquired. For stress dynamic acquisition, patient receives pharmacologic stress agent with IV Dipyridamole infusion at 0.56 $mg \cdot kg^{-1}$ over 5 minutes. After 7 minutes from the start of dipyridamole infusion, 25 mCi 99mTc-sestamibi is given followed by a flush volume of 35 mL normal saline to ensure consistent delivery of a tight bolus at 3 mL per second for about 13 seconds. The dynamic scan is acquired in list mode over 6 minutes. Following the stress dynamic scan, stress perfusion scan is acquired. **B** For 2 days protocol, 20 mCi of 99mTc-sestamibi is given for rest and stress dynamic perfusion scan, respectively. If no radiotracer activity is detected on the 2nd day, 1 mCi of 99mTc-sestamibi will be given for POS. The Dynamic data are reconstructed with Spectrum-Dynamic software and the analysis is performed in INVIA Corridor 4DM.

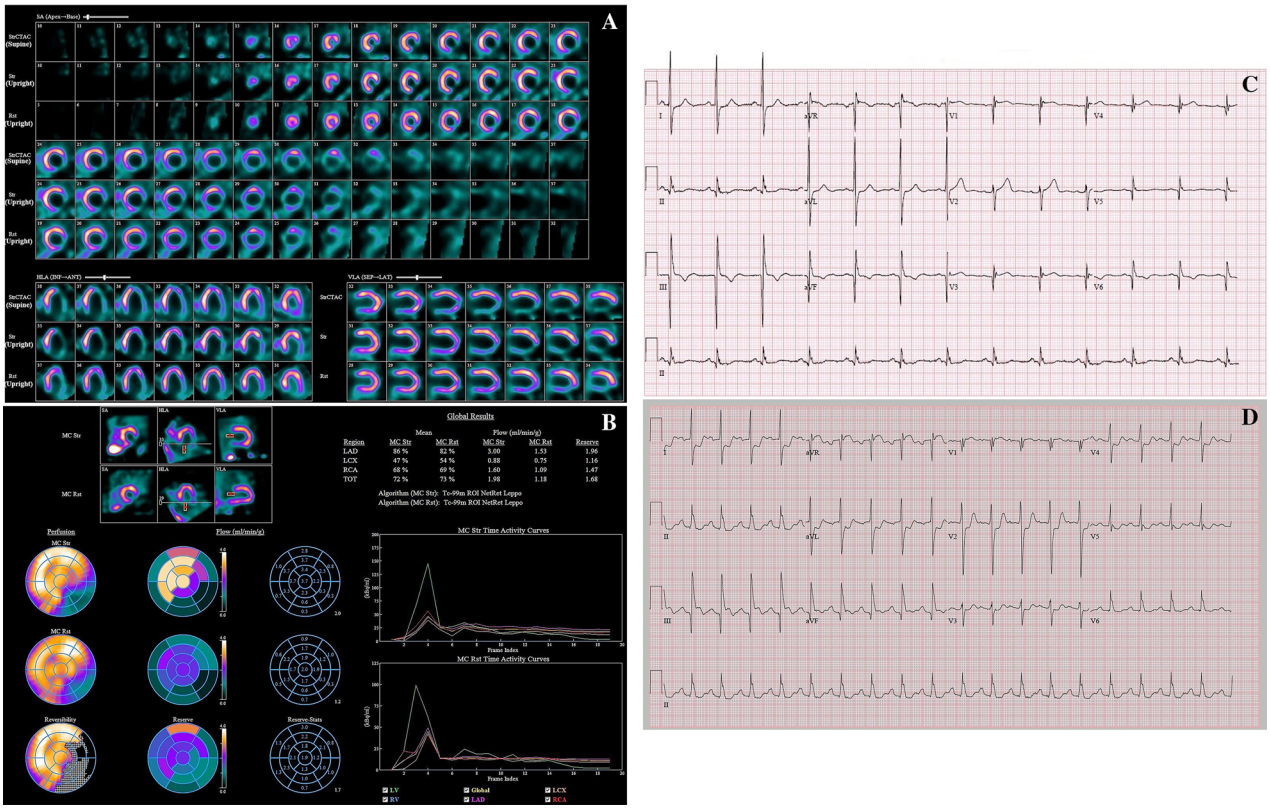

Figure 2. Transmural infarct with ischemia in inferolateral segments. **A**-**B** 61-year-old male presented with NSTEMI precipitated by GI bleeding. He had TVD 4 years ago (distal LM-30% stenosis, prox-mid LAD-70% stenosis, D1-90% stenosis, ostial LCX-90% stenosis, occluded OM1, OM2, and proximal RCA; there are collateral from distal LAD to OM1 and septal branches to PDA). He declined revascularization. Dynamic radionuclide MPI showed transmural infarct in basal to distal lateral wall extending to inferior wall with inducible ischemia in basal to distal anterolateral, inferior, and apical anterior wall. There was severely reduced MFR of 1.16 in LCX territory with relative marked reduction of both stress and rest MBF consistent with transmural infarct. (Normal MFR value is > 2 and normal stress MBF is > 2.5 mL·min^{-1}·g^{-1} based on PET imaging). The MFR in RCA territory was moderately reduced to 1.47 in keeping with peri-infarct ischemia. Post-stress LVEF dropped to 31% from rest LVEF of 44%. (**C**-**D**) There was marked ST depression during dipyridamole infusion.

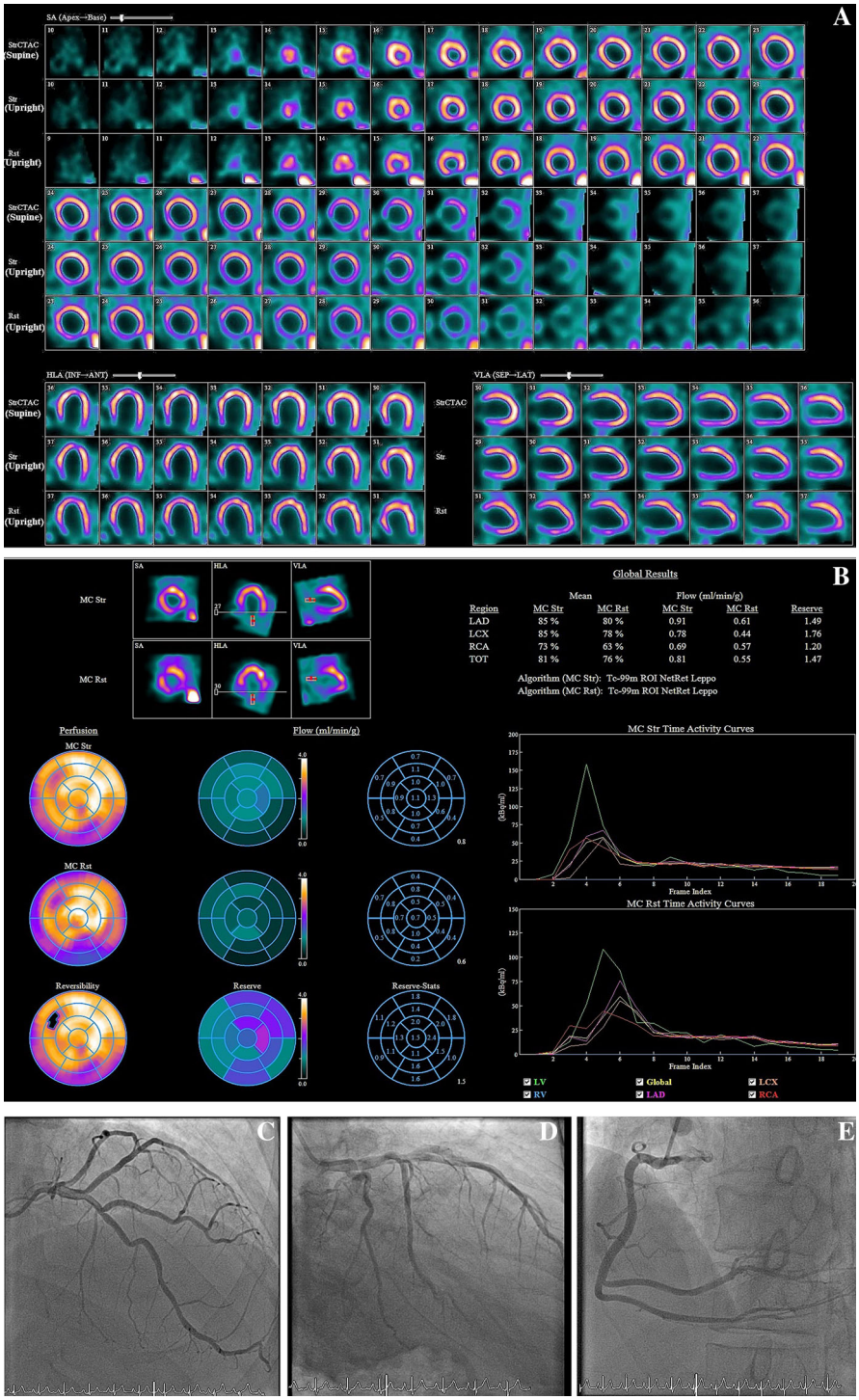

Figure 3. Dilated cardiomyopathy with microvascular dysfunction. **A**-**B** 66-year-old Chinese male was admitted for work up for fluid overload. TTE revealed severely reduced LVEF of 20% with dilated LV. Dynamic MPI showed reduced MFR in all coronary territories (LAD 1.49; LCx 1.76; RCA 1.20; Overall 1.47) despite normal perfusion. The stress MBF was reduced in all 3 coronary territories with value of < 1 mL·min^{-1}·g^{-1}. Coronary angiogram showed minor CAD. Overall this is likely a case of dilated cardiomyopathy. Retrospectively, the global reduction of MFR in this case could be due to microvascular dysfunction. Cardiac MRI will be useful to assess for midwall fibrosis as may be present in dilated cardiomyopathy which can also possibly account for the reduction of MFR. He is well tolerating the guideline-directed medical therapy. (**C**-**E**) Coronary angiogram showed minor coronary artery disease in mid LAD and proximal RCA with right dominant circulation.

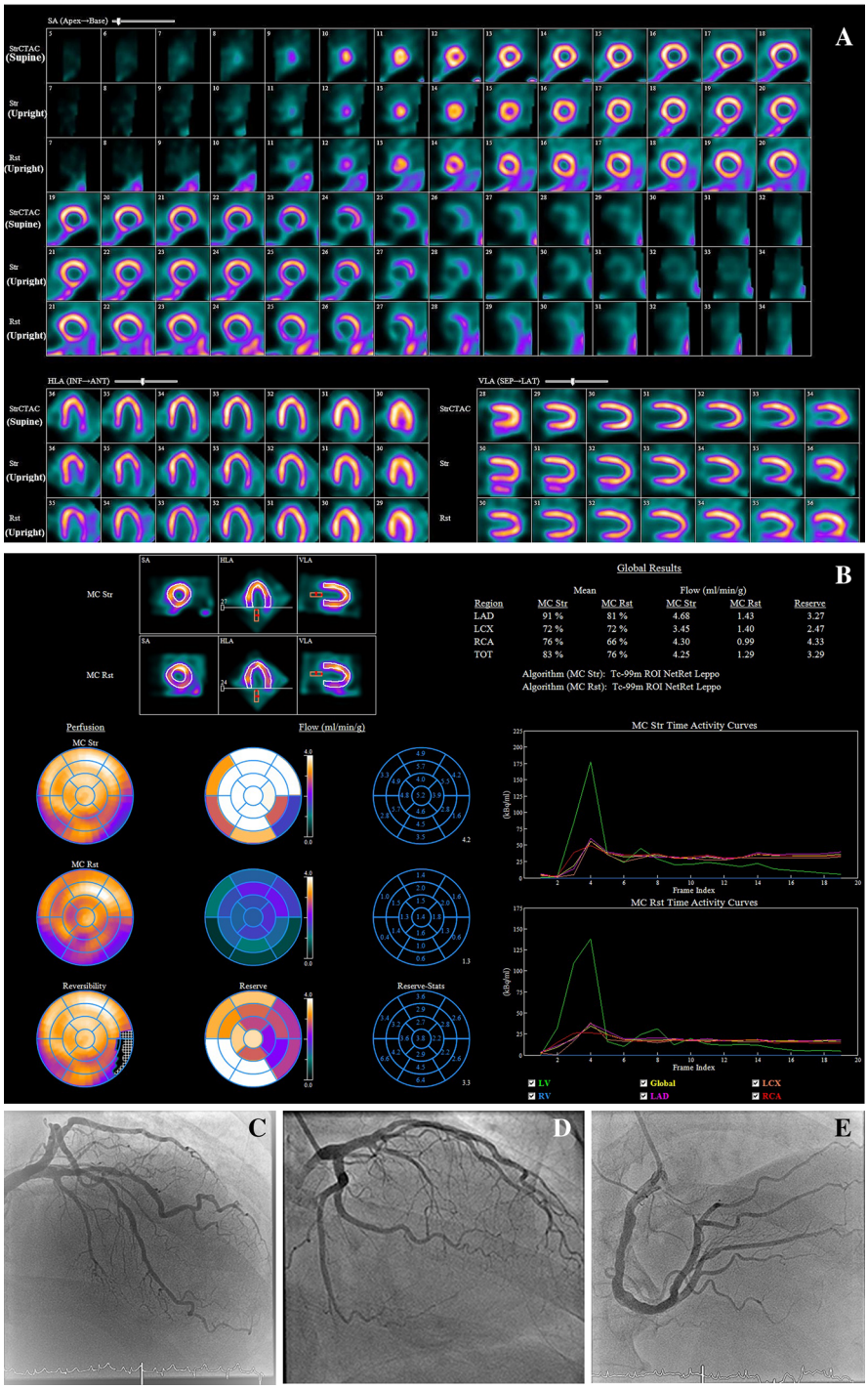

Figure 4. Partial thickness infarct with microvascular dysfunction. **A**-**B** 70-year-old male presented with inferior STEMI which was treated with primary PCI of distal RCA in 2006. He had recurrent chest discomfort. Dynamic radionuclide MPI showed partial thickness infarct with mild inducible ischemia in the basal to mid inferolateral segments and LVEF was normal. The LCX territory showed relatively reduced MFR of 2.47 compared to LAD 3.27 and RCA 4.33. (**C**-**E**) Coronary angiogram showed minor CAD in RCA with intermediate coronary artery stenosis in mid LAD and D1 branch. LCX was normal. The relative reduction of MFR in the conventional LCx territory actually reflected the inferolateral segments supplied by the RCA. The relative reduction in the MFR value could be due to the underlying partial thickness infarct in the inferolateral segments coupled with possible microvascular disease. FFR to the intermediate LAD lesion was not significant (0.82) and this was in keeping with the MFR value from the dynamic radionuclide MPI.

Disclosure

Thet Khaing, Ching Chiew Wong Raymond, Wan Xian Chan, Chen Hao, and Siong Sung Wong have no conflicts of interest to declare.

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