Myocardial perfusion imaging in overweight patients and women: Is it CZT good enough?

Gabriel Blacher Grossman, MD, PhD, FASNC[a,b]

[a] Nuclear Medicine Department, Hospital Moinhos de Vento, Porto Alegre, Brazil
[b] Cardionuclear, Instituto de Cardiologia, Porto Alegre, Brazil

Received Jan 30, 2019; accepted Jan 30, 2019
doi:10.1007/s12350-019-01656-5

See related article, pp. 755–768

Coronary artery disease (CAD) is still one of the first causes of morbidity and mortality among men and women. Conventional single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) is an important non-invasive tool to evaluate patients with known or suspected CAD. The sensitivity and specificity of this method is adequate for the diagnostic evaluation mainly in patients with intermediate pre-test probability of CAD and also it has important prognostic power for assessing the risk of cardiovascular events.[1] However, it has some limitations. Attenuation artifacts due to the biotype of patients may interfere with the final results of the study, especially in overweight, obese and women. Attenuation correction (AC) reduces the influence from tissues such as breast, diaphragm, abdomen, and lateral chest. It is well known that AC for conventional SPECT MPI studies improves diagnostic accuracy compared with non AC studies.[2] Also, conventional SPECT MPI evaluates perfusion semi-quantitatively, depending on the highest signal detected in the left ventricle. This limitation can underestimate the extent and severity of ischemia in high-risk CAD patients.[3]

It has been demonstrated that positron emission tomography/computed tomography (PET/CT) is superior to conventional SPECT MPI studies for the diagnosis of CAD and for risk stratification for future cardiovascular events.[4] AC through CT enhances specificity and improves image quality. The possibility to quantify myocardial blood flow (MBF) and myocardial flow reserve (MFR) allows the detection of high-risk CAD patients with diffuse and balanced myocardial ischemia. Unfortunately, most of the nuclear cardiology centers around the world do not have access to PET cameras and PET radiotracers due to economic reasons.

Recently, the emergence of cadmium-zinc-telluride (CZT) SPECT systems enabled the acquisition of images with a higher number of counts, higher quality images, ultrafast acquisitions, dose reduction, and similar diagnostic accuracy using the same radiotracers that are used for conventional SPECT MPI studies.[5] It is also possible to use CZT with CT AC systems to reduce artifacts, mainly in the inferior and inferolateral wall. In the absence of AC, prone position can reduce attenuation artifacts.[6] Recently, it has been demonstrated the possibility to measure MBF and MFR with CZT cameras.

In this issue of the Journal, Hyafil et al compared the diagnostic performance for the detection of myocardial ischemia of 82-Rb-PET-MPS and 99m-Tc-SPECT-MPS with CZT camera in overweight individuals and women.[7] Individuals with at least one positive MPS were referred for coronary angiography (CA) with fractional flow reserve (FFR) measurements. In the absence of CA occurrence of acute coronary event during the following year was considered an endpoint. Sensitivity for the detection of myocardial ischemia was higher with 82-Rb-PET-MPS compared to 99m-Tc-SPECT-MPS (85% vs 57%, $P < .05$); specificity was equally high with both imaging techniques (93% vs 94%, $P > .05$). Also, 82-Rb-PET-MPS allowed for a more accurate detection of patients with high risk coronary artery disease than 99m-Tc-SPECT-MPS (AUC=0.86 vs 0.75, respectively; $P = .04$). The difference in sensitivity between 82-Rb-PET-MPS and 99m-Tc-SPECT-MPS could be explained by the use of AC improving the quality of images in the 82-Rb-PET-MPS

Reprint requests: Gabriel Blacher Grossman, MD, PhD, FASNC, Nuclear Medicine Department, Hospital Moinhos de Vento, Porto Alegre, Brazil; *ggrossman@terra.com.br*
J Nucl Cardiol 2020;27:769–73.
1071-3581/$34.00

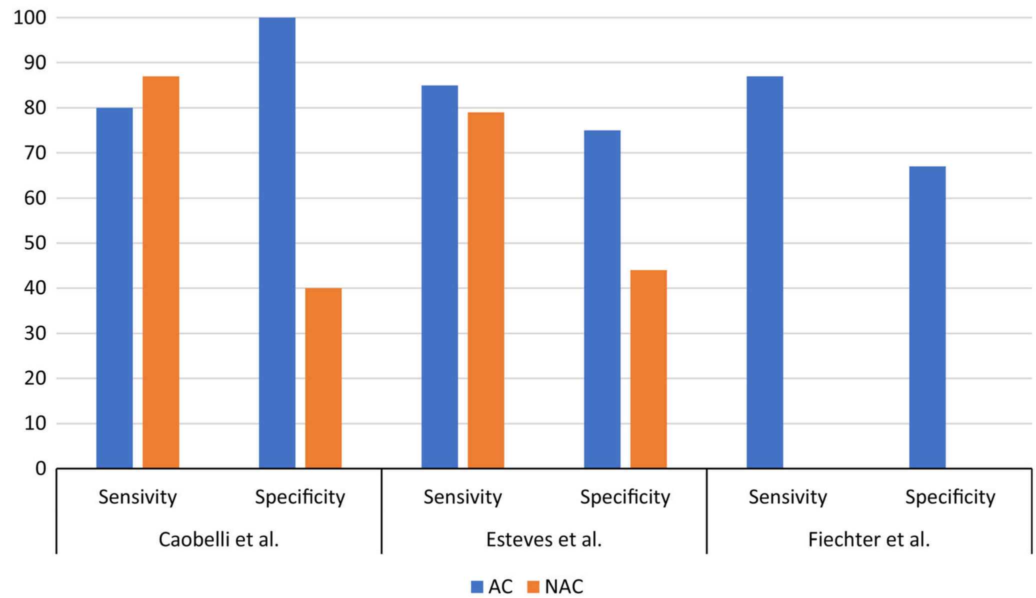

Figure 1. Effect of CT attenuation correction on the diagnostic accuracy of CZT-SPECT. This figure is reprinted from Peters et al.[6] and is licenced under CC BY 4.0.

exams and the possibility of quantifying myocardial flow and coronary flow reserve that allowed the detection of balanced myocardial ischemia in high-risk CAD patients.

The fact that no AC was performed in studies with 99m-Tc-SPECT-MPS is a limitation of the study and may have interfered in the results. Multiple studies have assessed the diagnostic performance of CZT-SPECT with CTAC, using invasive coronary angiography as a gold standard. Overall, these studies reported high sensitivities and reasonable specificities; however, the number of patients in each study was limited [8–10] (Figure 1). Other limitation pointed out by the authors of the study was the absence of MBF quantification using dynamic acquisitions in the CZT-SPECT MPI studies. There are currently softwares that allow the quantification of MBF and MFR with CZT systems, which would certainly increase the sensitivity of the studies. Agostini et al demonstrated the feasibility of myocardial blood flow and flow reserve estimation using a CZT camera in patients with stable CAD in comparison with ^{15}O-water PET and FFR. The sensitivity and specificity were 58.3 and 84.6 for the detection of hemodynamically significant stenosis (FFR $\leq$ 0.8) [11] (Figures 2 and 3). Recently, De Souza et al also documented the possibility of calculating MBF and MFR through CZT-SPECT dynamic acquisition studies.[12] MBF and MFR quantifications using CZT-SPECT need to be included in the routine of centers that use CZT cameras to grow the evidence of its use and improve the results of its application. Certainly, CZT flow quantification constitutes a current field of research that will generate knowledge and will enhance the applications of SPECT MPI in CAD.

Even without AC and MBF quantification, CZT cameras have very good accuracy in overweight, obese, and women. Gimelli et al evaluated the feasibility and diagnostic accuracy of stress/rest imaging with a CZT camera in obese patients. The authors demonstrated very good or excellent images in all patients (148; mean BMI 39 ± 7 kg/m^2).[13] De Lorenzo et al evaluated the prognostic value of myocardial perfusion SPECT obtained in CZT cameras in obese patients. Among 1396 patients that were submitted to a single-day, rest/stress imaging, 365 (26,1%) were obese (mean BMI 33.9 ± 3.6). Image quality was good/excellent in 94.5% of the obese patients. The annualized mortality rates were not significantly different among obese and non-obese patients, being < 1% with normal CZT studies and increased with the degree of scan abnormality in both obese and non-

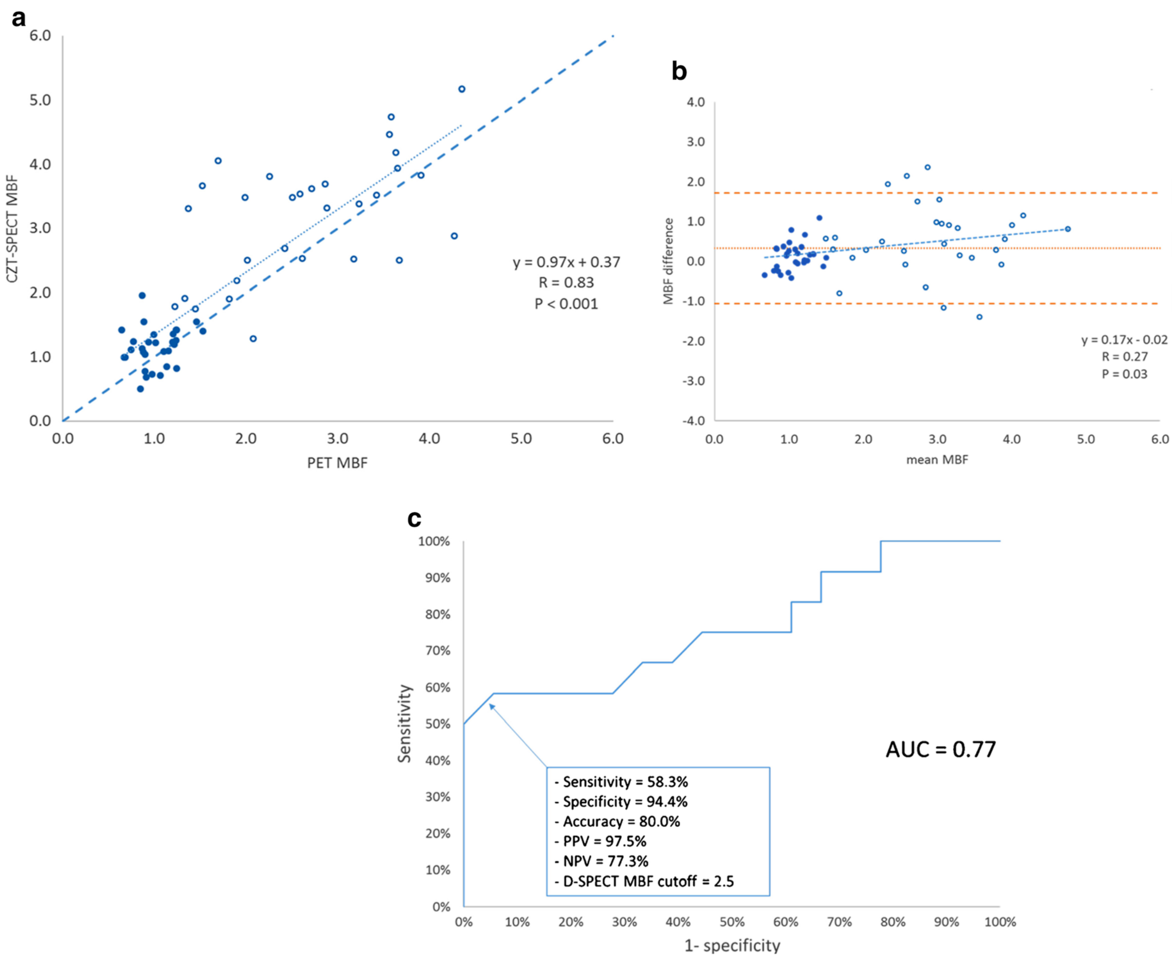

Figure 2. Correlation between global MBF (ml/min/g) by PET and by CZT-SPECT in 30 patients (rest: full circle; stress: empty circles). MBF estimates plotted against MBF measured by PET. **A** The dashed line is the fit obtained from total least square regression. **B** Bland-Altman plot showing the agreement between the two modalities in 30 patients for MBF (ml/min/g). **C** ROC curve showing the sensitivity and specificity of CZT-SPECT for the diagnostic of abnormal stress PETMBF (< 2.5 ml/min/g). This figure is reprinted from Agostini et al.[5] and is licenced under CC BY 4.0.

obese patients.[14] Gimelli et al evaluated gender-related differences in diagnostic accuracy of CZT-SPECT MPI in detecting single and multi-vessel CAD. All patients underwent coronary angiography within 30 days. Global SSS was the best predictor of CAD in women (AUC = 0.866, 81% sensitivity and 79% specificity) and in men (AUC = 0.871, 76% sensitivity and 84% specificity). There were no gender-related differences in terms of diagnostic accuracy.[15] Although the results of the study of Hyafil et al demonstrated the superiority of PET MPI over CZT-SPECT MPI studies, CZT systems have very good diagnostic accuracy in these subgroups of patients. The use of AC and MBF quantification could help to improve the value of this technology in overweight, obese, and women.

It is worth noting that in several countries of the world the availability of cutting-edge equipment such as cardiac PET/CT and CZT is still a rarity. Conventional SPECT MPI is still the most frequent technology in several centers. We must stimulate the realization of

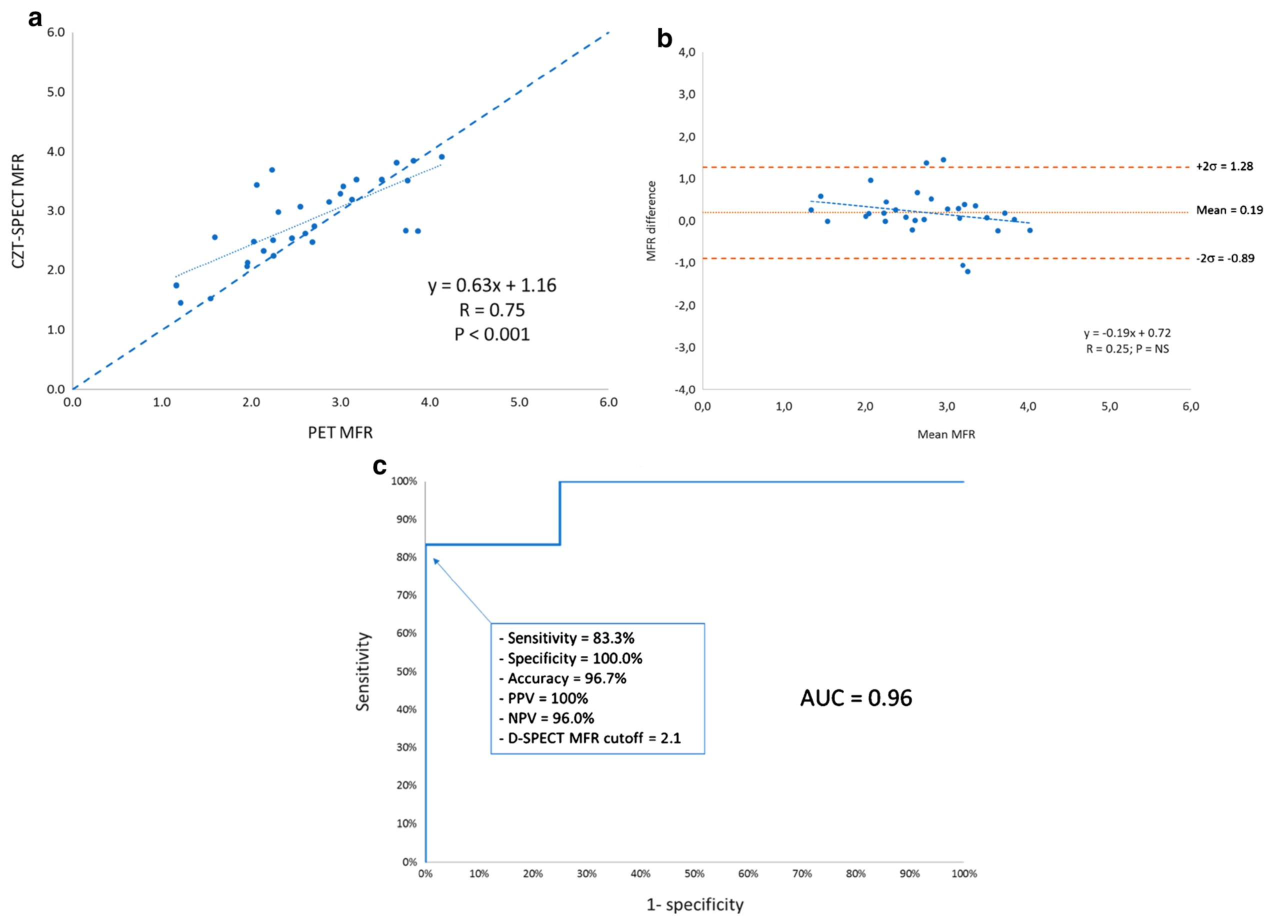

Figure 3. Correlation between PET and CZT-SPECT for global MFR in 30 patients. MFR estimates by CZT-SPECT plotted against MFR measured by PET. **A** The dashed line is the fit obtained from total least square regression. **B** Bland-Altman plots between PET and CZT-SPECT for global MFR in 30 patients. **C** ROC curve showing the sensitivity and specificity of CZT-SPECT for the diagnostic of abnormal stress PET MFR (< 2). This figure is reprinted from Agostini et al.[5] and is licenced under CC BY 4.0.

nuclear cardiology scans with the best possible quality in these centers, using iterative reconstruction and attenuation correction if possible.

Disclosure

The author has no conflict of interest.

References

1. Hendel RC, Berman DS, Di Carli MF, et al. ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 appropriate use criteria for cardiac radionuclide imaging: A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the American Society of Nuclear Cardiology, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society of Nuclear Medicine. Circulation 2009;119:e561-87.
2. Grossman GB, Garcia EV, Bateman TM, et al. Quantitative Tc-99m sestamibi attenuation-corrected SPECT: development and multicenter trial validation of myocardial perfusion stress gender-independent normal database in an obese population. J Nucl Cardiol 2004;11:263-72.
3. Lima RSL, Watson DD, Goode AR, et al. Incremental value of combined perfusion and function over perfusion alone by gated SPECT myocardial perfusion imaging for detection of severe three-vessel coronary artery disease. J Am Coll Cardiol 2003;42:64-70.
4. Ziadi MC, Dekemp RA, Williams K, et al. Does quantification of myocardial flow reserve using rubidium-82 positron emission tomography facilitate detection of multivessel coronary artery disease? J Nucl Cardiol 2012;19:670-80.
5. Agostini D, Marie P, Ben-Haim S, et al. Performance of cardiac cadmium-zinc-telluride gamma camera imaging in coronary artery disease. A review from the cardiovascular committee of the european association of nuclear medicine (EANM). Eur J Nucl Med Mol Imaging 2016;43:2423-32.

6. Peters A, Kumar J, Patil PV. Diagnostic implications of CZT - SPECT and impact of CT attenuation correction. J Nucl Cardiol 2017. https://doi.org/10.1007/s12350-017-0961-5
7. Hyafil F, Chequer R, Sorbets E, et al. Head-to-head comparison of the diagnostic performance of Rubidium-PET and SPECT with CZT camera for the detection of myocardial ischemia in a population of women and overweight individuals. J Nucl Cardiol 2018. https://doi.org/10.1007/s12350-018-01557-z
8. van Dijk JD, Mouden M, Ottervanger JP, et al. Value of attenuation correction in stress only myocardial perfusion imaging using CZT-SPECT. J Nucl Cardiol 2017;24(2):395-401.
9. Caobelli F, Akin M, Thackeray JT, et al. Diagnostic accuracy of cadmium-zinc-telluride-based myocardial perfusion SPECT: Impacto f attenuation correction using a co-registered external computed yomography. Eur Heart J Cardiovasc Imaging 2016;17(9):1036-43.
10. Esteves F, Galt J, Folks R, Verdes L, Garcia E. Diagnostic performance of low-dose rest/stress tc-99m tetrofosmin myocardial perfusion SPECT using the 530c CZT camera: Quantitative vs visual analysis. J Nucl Cardiol 2014;21(1):158-65.
11. Agostini D, Roule V, Nganoa C. First validation of myocardial flow reserve assessed by dynamic $_{99m}$Tc-sestamibi CZT-SPECT camera: head to head comparison with $_{15}$O-water PET and fractional flow reserve in patients with suspected coronary artery disease. The WATERDAY study. Eur J Nucl Med Mol Imaging 2018;45(7):1079-90.
12. de Souza ACAH, Gonçalves BKD, Tedeschi A, Lima RSL. Quantification of coronary flow reserve with CZT gamma camera in the evaluation of coronary artery disease. Arq Bras Cardiol 2018;111:635-7.
13. Gimelli A, Bottai M, Giorgetti A, Genovesi D, Filidei E, Marzullo P. Evaluation of ischaemia in obese patients: Feasibility and accuracy of a low-dose protocol with a cadmium-zinc telluride camera. Eur J Nucl Med Mol Imaging 2012;39:1254-61.
14. De Lorenzo A, Peclat T, Amaral AC, Lima RS. Prognostic evaluation in obese patients using a dedicated multipinhole cadmium-zinc telluride SPECT camera. Int J Cardiovasc Imaging 2016;32:355-61.
15. Gimelli A, Pugliese NR, Kusch A, Giorgetti A, Marzullo P. Accuracy of cadmium-zinc-telluride imaging in detecting single and multivessel coronary artery disease: Is there any gender difference? Int J Cardiol 2019;1:388-93.